MEMOIRS OF THE

DEPARTMENT OF AGRICULTURE IN INDIA

ENTOMOLOGICAL SERIES

Volume V

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR
THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

PRINTED BY
THACKER, SPINK AND CO.
CALCUTTA.

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Vol. V

PREFACE

This Memoir contains information which has been accumulating for some years and includes accounts of life-histories of practically all the butterflies which are of economic importance in India. The observations have been carried out in the Pusa Insectary under the direction of the Imperial Entomologist. The account of the Rice Leaf Caterpillar (*Melanitis ismene*) was written some time ago by Mr. H. Maxwell-Lefroy, formerly Imperial Entomologist, but was not published and is included in this Memoir. In writing the account of the Cabbage White the notes of Mr. R. D. Koppikar have been used.

A. J. GROVE,
Offg. Imperial Entomologist.

PUSA,
September 18th, 1913.

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LIFE-HISTORIES OF INDIAN INSECTS--V.

LEPIDOPTERA (Butterflies).

BY

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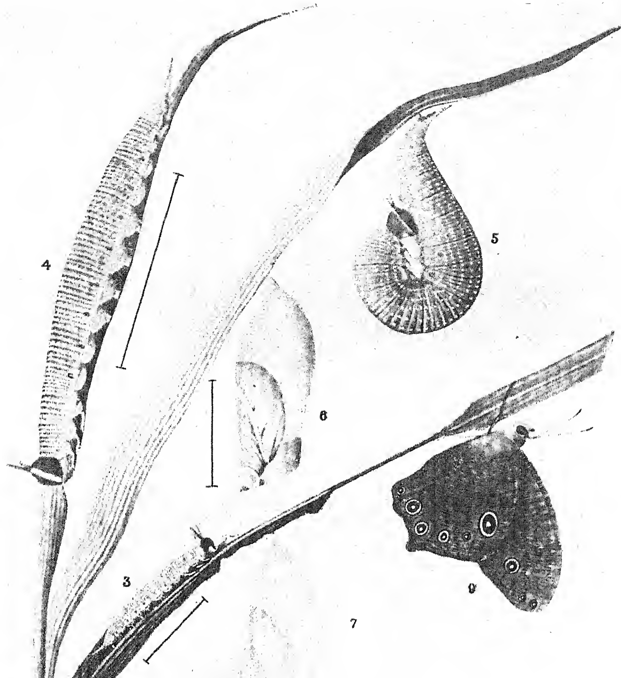
INTRODUCTION.

THE insects, the life-histories of which are described in this volume, are representatives of the principal families of that interesting group of insects, the Butterflies. With the exception of one (Delias) the others are pests of more or less economic importance, occurring on trees and plants either cultivated or grown for the garden. All are of interest and importance in that they are probably the first to attract the attention of the beginner in Entomology, especially Economic Entomology. Also they occur so constantly and are so common that in all their stages, they frequently come under the notice of even the common people, but for want of a proper knowledge and observation ordinary people fail to see the connection between the caterpillar which eats the leaves, the dormant pupa and the butterfly which incessantly flies about under trees, over bushes and plants and not infrequently in houses or even over one's head. The hanging Nymphalid, Papilionid and Pierid pupæ are frequently mistaken for fruits by many. For the progress of Economic Entomology in India it is essential that the people should become familiar with the insects and especially with their life-history. The greatest bar to progress in checking injurious insects here is the fact that a mysterious origin is usually assigned to them, simply because the elementary and essential facts of insect transformations are not known to those who suffer from the depre-

dations of the insects. The life-history of the insects described in this volume is easily observed. The caterpillars thrive in captivity, requiring only a daily supply of fresh leaves until they pupate. The stages figured in the plates are easily seen. For this reason any one of these insects can be recommended as an object-lesson to teachers.

Under each insect the recent literature is quoted, where the reader will find references to the systematic literature dealing with it. The reader is also referred to the account of the common butterflies of the plains of India appearing in the Journal of the Bombay Natural History Society, Vol. XIX *et seq.*, where Mr. T. R. Bell has given new descriptions of almost all the species dealt with in this volume.



RICE LEAF CATERPILLAR.

EXPLANATION OF PLATE I.

Melanites ismene, Cram.

The Rice Leaf Caterpillar.

Fig. 1. Eggs as laid on leaf.
„ 2. Single egg, magnified.
„ 3. Young larva.
„ 4. Full-grown larva.
„ 5. Pupating larva.
„ 6. Pupa.
„ 7. Empty pupa case.
„ 8 & 9. The butterfly.

MELANITIS ISMENE, Cr.

The Rice Leaf Caterpillar.

(Plate I).

[Bingham, Fauna of India, Butterflies, Vol. I, 1905, p. 158.]

Distribution.—Africa, Madagascar, Mauritius, Bourbon. Indo-Malayan region to Australia. In India, common in Bengal, Central and Peninsular India; also in Assam, Burma, Ceylon, rare in the Punjab and Himalayas, common in the United Provinces (de N.).

Broods.—The complete life-cycle of one batch is as follows:—Eggs laid on the 3rd October, hatched 6th October, larvæ pupated 28th and 29th October, butterflies emerged 8th and 9th November; this gives a total of 36 to 37 days from egg to imago. There is a brood that emerges as butterflies in August-September, presumably the "Wet-season" form; these lay eggs in October and emerge in November and live over until July or breed earlier if food is available.

Food-plants.—Rice (*Oryza sativa*) is a common food-plant, though the larvæ rarely occur on it in any abundance in one place. Juar (*Andropogon sorghum*) is another. Moore says that it generally "feeds on grasses."

Life-history—The egg.—The butterfly lays eggs on the lower surface of the leaf of the food-plant, one or a few eggs at a time, usually in a row, the eggs close together (Plate I, fig. 1). Eggs are laid during the day, the butterflies being inactive at night. In the Insectary great difficulty was experienced in getting eggs at all and the number normally laid in the open has not been ascertained.

Each egg is spherical with a flattened base, smooth, without any ornamentation; it measures about 1 mm. in diameter; the

colour is creamy white when first laid, but before hatching a black spot appears at the apex, marking the head of the caterpillar within. Eggs hatched within three days from the time of deposition; the emergence of the caterpillar takes place through a hole it gnaws in the shell after which the remainder of the empty shell is wholly or partly eaten.

The larva.—The newly-hatched larva is about 2 mm. long; the head is black, larger in section than the body and with the long axis vertical; the processes characteristic of the later stages are scarcely perceptible. The body is cylindrical, white with a faint green tinge, becoming green in the course of the first day. The five pairs of prolegs are fully developed and the processes at the hind end are perceptible though very small.

On hatching and after having eaten the egg-shell, leaving as a rule only the base which is fastened to the leaf, the larvæ remain motionless on the rice-leaf; their attitude is always the same, the body parallel to the midrib and close to it; when several are on one leaf they rest close together one behind the other; at intervals they feed on the edge of the leaf and they remain on the leaf until the first moult is passed. Throughout larval life the habits vary little; the green larva rests on the underside of the leaf, parallel to the midrib, lying along the narrow rice or grass-leaf; the colouring, attitude and habits are cryptic, designed to conceal the larva and figure 4 in Plate I illustrates clearly how markedly cryptic this is. During the day, larvæ move little and they feed more at night; feeding is done at intervals during the day especially by young larvæ; from above one sees only the black head appearing at the margin and it is difficult to find larvæ in the field except by looking for bitten leaves.

There are five larval moults, the last revealing the pupa; feeding ceases for a day before moulting as is usual in caterpillars; the integument of the body is shed quickly and easily, the head-case being shed separately and apparently with greater difficulty. The head is green after the moult. The larva feeds by bending

over to the margin of the leaf till it is able to bite from the edge inwards; it eats into the midrib in many cases, but as its head has little play, the body remaining fixed, the eaten leaf is very characteristic, curved pieces being eaten out of each side as far as the midrib (Plate I). Young larvæ remain together on one leaf and rest only on the middle; older larvæ scatter, and may fix themselves near the margin and so be able to feed more easily; full-grown larvæ eat the midrib also. The following are the dates of the moults :—Two larvæ hatched 6th October, first moult 9th, second moult 12th, third moult 15th, fourth moult 20th, final moults 28th and 29th. The instars may be shortly described as follows :—

First instar.—Length 4 mm. Head deep-brown to black, the front vertical, the circumference greater than that of any segment. The processes are small, yellow and covered with black spines. Body cylindrical, segments distinct, each segment with transverse wrinkles; a few long hairs on each segment, as well as many short white hairs on white tubercles. The anal processes project directly behind the body, greenish in colour with short black spines.

Second instar.—Length 6 mm. Side of the head and mouthparts yellowish. Head processes black, longer, thicker and with a yellow knob. A dorso-lateral white stripe runs from the prothorax to the hind end; the white tubercles are more marked.

Third instar.—Length 9 mm. Head black, green round the mouthparts, with a triangular green space on the frons, the sides green with a white line along each cheek; the processes black. The body shows a broad mid-dorsal green stripe, bordered by an indistinct white line; the white dorso-lateral stripe is broader and below the spiracles, there is a faint yellowish line. The white tubercles are prominent giving the body a speckled appearance. (Plate I, fig. 3).

Fourth instar.—Length 14 mm. Body thicker at and behind the fourth abdominal segment. Head green, mouthparts dark brown; there is a lateral white band stretching from the base of the processes to the mouthparts which is in some specimens bordered with black, in others continued on the processes which are then brown in front, white behind.

Fifth instar.—Length 30 mm. at first, increasing to 45 mm. Head green with a broad lateral white stripe, often bordered with black; processes red-brown; both head and processes are covered in thin black and grey hairs. Body tapering markedly from the fourth abdominal segment (6 mm. across) to the

prothorax (3 mm. across); the segments are less distinct, the white tubercles form irregular interrupted lines and there are seven transverse wrinkles to each segment. The anal processes are green, with black hairs. The spiracles are oval, black rimmed; the legs and prolegs green.

Throughout larval life the colouring, form and attitude are cryptic and this is carried out in small details; the dark head of the younger stages and the processes on the head alone appear to be incompatible with this object; the body tapers off behind very gradually into the anal processes which lie flat on the leaf; there is no marked rounding off behind which would throw a marked shadow, and the clothing of white and black hairs probably aids in softening shadows and masking the definite outlines of a curved solid body. The more marked lateral white stripes in the younger stages give place to the more indefinite broken lines in the larger insect, both being probably effectual in rendering the larva inconspicuous.

The pupa.—The full-fed larva spins a small network of silk on the underside of a leaf and then hangs head down by the anal prolegs, the body curving inwards ventrally (Plate. I , fig. 5). In this attitude it rests for 16 to 20 hours; the body is then stretched till it is almost straight, the skin bursts along the mid-dorsal thoracic line and the end of the pupa appears through the split; the larval head case then splits along the vertex and the front half of the larval skin slips back, leaving the thoracic half of the pupa free; the ruptured larval skin then slides backwards over the pupa till it only surrounds the abdomen of the pupa; the extreme anal apex of the pupa is then brought out of this skin and is struck into the net woven by the larva, the curved hooks on the apex engaging in the silk and, by a twisting of the pupa, getting firmly twisted in the fibres; for one brief instant then the pupa would appear to have no support (between the emergence of the apex of the abdomen and its engaging in the silk), but actually the pupa is during this instant suspended by two knobs on the penultimate anal segment, which are curved forwards, away from the apex of the abdomen, and which engage in the larval skin as it

slips backwards and so arrest the fall of the pupa long enough for it to strike the apex of its abdomen into the silk and twist itself round. The larval skin is then free and, the contraction of the anal prolegs no longer fastening it to the leaf, it falls away leaving the pupa hanging (Plate I , fig. 6). The above action occupies only a few seconds. The pupa is about 21 mm. long, 8 mm. across, the stalk at the apex of the abdomen about 1·5 mm. long. There are seven pairs of spiracles; the developing eyes, wings, legs and antennæ are clearly distinguishable in the later stages of pupation. The pupal period is about 10 days.

The imago.—Emergence of the imago takes place by the rupture of the pupa-case along the position of the antennæ (Plate I, fig. 7). The butterflies emerge, cling to the pupa-case till its wings are spread and hardened, which takes place in one to two hours. The butterflies are diurnal, and are found commonly flying about the trunks of large trees and settling on the ground below them; they frequent only shady places and may be seen flying actively and playing together in such places.

ERGOLIS MERIONE, CRAM.

THE CASTOR SPINY CATERPILLAR.

(PLATE II).

[Bingham, Fauna of India, Butterflies, Vol. I, 1905, p. 462.]

Bingham takes Westwood's *E. taprobana* as the Southern Indian and Ceylon race of *E. merione,* but it is evidently a distinct species and is not a castor-feeder at all (T. B. F.) Moore's *E. tapestrina* is taken by de Niceville as an aberration or sport of *E. merione* and Bingham agrees with him.

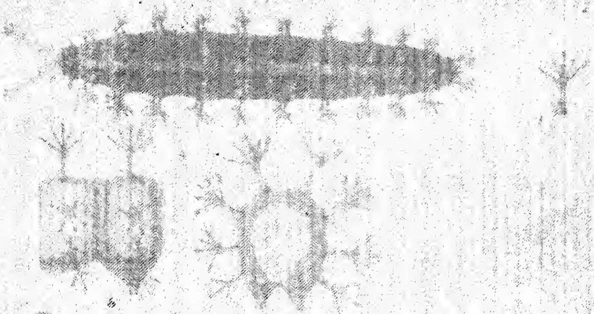
Distribution. (*E. merione*).—The northern half of Continental India, Simla to Sikkim in the Himalayas, and recorded from Rajputana and Bengal; Assam, Burma, Tennasserim, Malayan Subregion. (*E. taprobana*). Southern India, Ceylon. (Bingham).

Food-plant and damage.—The larva feeds on castor (*Ricinus communis*) leaf. It is a minor pest and there seems to be hardly any likelihood of its turning into a serious one.

Life-cycle.—*Ergolis merione* is active throughout the year. There is no actual hibernation, but as will be evident from the table given below, the periods of the different stages are lengthened in the cold weather so that the life-cycle in winter is about three times as long as in the warmer weather.

Egg laid.	Egg hatched.	Larva pupated.	Butterfly emerged.	Periods in days.
18 Aug.	21 Aug.	31 Aug.	7 Sept.	3 + 10 + 8 = 21
19 ,,	22 ,,	31 ,,	7 ,,	3 + 9 + 8 = 20
20 ,,	23 ,,	4 Sept.	11 ,,	3 + 12 + 7 = 22
14 Sept.	17 Sept.	27 ,,	2 Oct.	3 + 10 + 5 = 18
14 ,,	17 ,,	27 ,,	3 ,,	3 + 10 + 6 = 19
15 Nov.	20 Nov.	25 Dec.	14 Jany.	5 + 35 + 20 = 60
15 ,,	20 ,,	26 ,,	17 ,,	5 + 36 + 22 = 63
25 ,,	1 Dec.	1 Jany.	25 ,,	6 + 31 + 24 = 61

PLATE II.



EXPLANATION OF PLATE II.

ERGOLIS MERIONE, CRAM.

The Castor Spiny Caterpillar.

Fig. 1. Egg looked at from above X 18.
,, 2. Egg looked at from a side X 18.
,, 3. Larva, in the fourth stage.
,, 4. Larva, full-grown.
,, 5. Second and third abdominal segments of larva enlarged.
,, 6. Section of larva through third abdominal segment to show arrangement of spines.
,, 7. A spine drawn separately.
,, 8. Pupa, dorsal view
,, 9. Butterfly, dorsal view.
,, 10. Butterfly, ventral view.

The natural sizes of the stages are indicated by the hair-lines.

THE CASTOR SPINY CATERPILLAR.

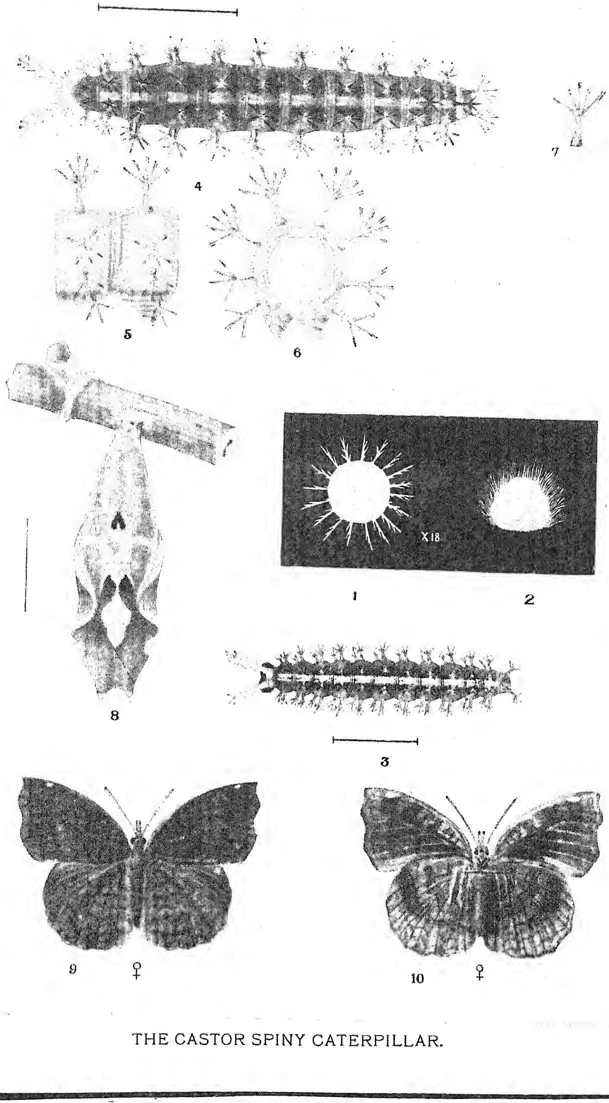
Distribution.—[illegible] half of Continental India, Simla to Sikkim [illegible] putana and Bengal. Assam [illegible] region. (*E.* [illegible]). Southern India [illegible]

[illegible] any likelihood of its turning into a serious [illegible]

Life-cycle.—*Ergolis merione* is [illegible] the year. There is no actual hibernation, [illegible] from the table given below, the periods of the [illegible] lengthened in the cold weather [illegible] is about three times as long as in the warmer weather.

Egg laid.	Egg hatched.	Larva pupated.	Butterfly emerged.	Periods in days.
[illegible] Aug.	21 Aug.	31 Aug.	[illegible] Sept.	[illegible]
[illegible]	22 ,,	31 ,,	[illegible]	[illegible]
[illegible]	22 ,,	4 Sept.	11 ,,	[illegible]
[illegible] Sept.	17 Sept.	27 ,,	2 Oct.	[illegible]
[illegible]	17 ,,	27 ,,	[illegible]	[illegible]
[illegible] Nov.	30 Nov.	23 Dec.	14 Jan.	[illegible]
[illegible]	30 ,,	26 ,,	17 ,,	[illegible]
25 ,,	1 Dec.	1 Jan.	25 ,,	[illegible]

PLATE II.



THE CASTOR SPINY CATERPILLAR.

[illegible]

The egg.—The butterfly deposits eggs singly on the under-surfaces of leaves, sometimes but much less commonly on their upper surfaces and rarely on the petioles. The butterflies being diurnal in habit, eggs are laid only during the day time. It is very difficult to make the butterflies breed in confinement. In the Insectary eggs were obtained from only one female which emerged on 14th September, mated in the afternoon of the 17th and laid 36 eggs, *viz.*, seven in the afternoon of the 18th, twenty-three in the morning of the 19th, and six in the same afternoon; she died the same night. Of these eggs only three were deposited on the upper surfaces of leaves, the remainder being on the lower surfaces. Each egg (Plate II, figs. 1 & 2) is dome-shaped with a flattened base and measures about $\frac{1}{2}$ mm. vertically and is about $\frac{2}{3}$ mm. from side to side, the diameter of the flattened base being about $\frac{1}{2}$ mm. From the periphery of the micropylar depression at the top of the egg, ridges and furrows run down the sides in regular order. The ridges vary in number from eighteen in some to twenty in others and are surmounted with long thin hairs, the furrows and the micropyle being free. The egg, therefore, looks hairy; figure 1 represents it as seen directly from above and figure 2 from the side. The colour of the egg with the hairs is uniform white. The eggs take about three days to hatch in summer temperature and six days or more in winter. The young caterpillar emerges by gnawing a hole in the shell and then eats it either partly or wholly; sometimes the portion of the leaf on which the base of the egg is fastened is also eaten, a small hole being produced in the leaf.

The larva.—After hatching from the egg the larva lives and feeds on the leaves of the plant until it is ready to pupate. It either bites holes in the middle of the leaf or eats from the edge. It feeds both during the day time and at night and is in the habit of taking rest occasionally and not eating continuously like many other caterpillars. Hence it produces holes here and there in the leaf and never reduces it to mere skeleton of veins like the semilooper caterpillar (*Ophiusa melicerte*). It often rests on the upper

surface of the leaf just above the junction with the petiole and on the spot whence the big veins arise. It rests in a peculiar attitude, the middle of the body being partly looped up and the hind end somewhat raised in the air. When it rests in this position the broad yellow stripe in the middle of its green back usually coincides with one or other of the big broad veins which too are of a lighter colour than the surface of the leaf. Not infrequently again the caterpillar will be found to sit similarly on a vein on the upper surface of the leaf, so that the stripe on its back appears in a line with the vein. Although this habit strikes one as peculiar, the larva may not uncommonly be found anywhere on the leaf either on its upper or lower surface. After hatching from the egg the larva passes through five moults pupating at the last. The following are the records of moults of two larvæ kept under observation :—

Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.
28th July 23rd Aug.	30th July 26th Aug.	1st Aug. 28th Aug.	3rd Aug. 30th Aug.	5th Aug. 1st Sept.	7th Aug. 4th Sept.

The process of casting off the first four moults is different from that of the fifth, in that the head moult is cast off separately in the former; the several hours of rest before the skin is shed are taken up mainly in extricating the head and then the skin is slipped off the body within about a minute, the moult of the head being also rubbed off at the same time. The larva moves forward a little from the rejected skin which sticks to the place, and after about half-an-hour's rest turns round and eats the cast skin completely. The same habit of taking rest while feeding may in some cases be noticed here as well; thus one larva ate about two-thirds of the skin and then took a long rest of thirty-six minutes before it ate the remaining portion. It is very interesting to note the behaviour of the horns and spines in the process of moulting; their branches remain folded on them and those forming the rosette at the top remain closed; the horns are short and lie on the sides of the head

as flabby pieces of skin and the spines on the body lie similarly with their ends pointing posteriorly. As soon as the head moult is cast and the skin is slipped off and even before the latter is freed from the hind end the horns and the spines begin to stand up and their branches to open. When they lie as flabby pieces of skin they are yellow in colour and it is distinctly perceptible that a green fluid is injected into them from the body and that it is the tension produced by this fluid which causes the spines to stand up and become rounded and stretched and the branches and rosettes to open out. The gradual spread of the green fluid is clearly observable. Within about six minutes from the time of actual moulting the spines and horns assume their normal appearance. When the larva hatches from the egg it does not possess either the horns on the head or the spines on the body ; they appear after the first moult and grow and become more branched with the growth of the caterpillar. The colour of the young larva is pale-yellow, but it soon acquires a tinge of green which deepens later on. The full-grown larva is green in colour, possesses big branching horns on the head and branching spines on the segments of the body and a prominent broad yellow mid-dorsal stripe.

The following is a description of the instars :—

First instar.—The larva when hatched from the egg measures about $1\frac{1}{2}$ mm. and grows to about 3 mm. before it is ready to undergo the first moult. It is cylindrical in shape and pale-yellow in colour which changes to green when food is taken. The metathorax and the first and seventh abdominal segments are brown on the back. There is no sign of horns on the head or of spines on the segments of the body which are so characteristic of the grown-up larva. The head is yellow and covered with black hairs and has got a black spot above the clypeus on each side. The body is also covered with longish hairs which are black in the dorsal region and white in the lateral parts. There are five pairs of equally developed prolegs.

Second instar.—The larva is about 5 mm. long and cylindrical in shape. It develops horns on the head and spines on the body after the first moult. The head is flat in front and yellow with a white patch above the clypeus and a big black spot on each cheek ; a horn about $\frac{1}{3}$ mm. long and of the same colour as the head appears on each lobe and is provided with spine-like hairs. The prothorax possesses no dorsal plate and has developed six small fleshy spines

and other smaller ones like small tubercles, each surmounted with black or white hairs ; the arrangement of the prothoracic spines does not conform to the arrangement of the spines on the other segments of the body. The meso-thorax, meta-thorax and all the abdominal and anal segments have developed branched or unbranched spines which are arranged in rows, *viz.*, the sub-median rows running on each side of the median line, the supra-spiracular rows running above the spiracles, the infra-spiracular rows running below the spiracles and the sub-infra-spiracular rows running just above the legs. The meso-thorax and meta-thorax have no infra-spiracular spines. Of the abdominal segments the seventh has no sub-infra-spiracular and the eighth no supra-spiracular or sub-infra-spiracular spines, but each has unlike all the other segments an extra spine in the median line. The anal segment possesses only the sub-median spines.

The arrangement of the spines on each side of the body excepting the prothoracic spines and the median ones on the seventh and eighth abdominal segments is shown in the subjoined table :—

	Meso-thorax.	Meta-thorax.	Abdominal segments.								Anal segment.
			1st	2nd	3rd	4th	5th	6th	7th	8th	
Sub-median ..	1	1	1	1	1	1	1	1	1	1	1
Supra-spiracular	1	1	1	1	1	1	1	1	1	0	..
Infra-spiracular..	0	0	1	1	1	1	1	1	1	1	..
Sub-infra-spiracular	1	1	1	1	1	1	1	1	0	0	..

The sub-median spines on meso-thorax and meta-thorax have their branches arranged at the top in the form of a rosette, as shown in figures 5, 6 & 7 of Plate II. The median spines on seventh and eighth abdominal segments and all the sub-median spines excepting those on meso-thorax and meta-thorax and the first abdominal segment are big and branching to a less extent and have no rosette at the top ; the branches on all these spines are surmounted by a black-pointed needle-like hair. The sub-median spines on the first abdominal segment and all the supra-spiracular and infra-spiracular spines are smaller than the other sub-median spines and are not as markedly branching, having small protuberances like tubercles surmounted with hairs. The sub-infra-spiracular spines are very small like small fleshy tubercles surmounted with a white hair. The colour of the larva is yellowish green, the meta-thorax and the third and seventh abdominal segments being brown in the dorsal area with the sub-median and median spines on them of the same colour ; there is a narrow brown stripe running on each side below the sub-median spines from the meta-thorax to the seventh

abdominal segment. There is a narrow deeper green median stripe noticeable between meta-thorax and seventh abdominal segment, this showing the course of the dorsal vessel.

Third instar.—After the second moult the larva is about 6 mm. long and grows to about 8 mm. before it is ready for the third moult. In shape it is the same as in the previous instar. The head is now shiny black with a white patch above the clypeus ; the horns are about 1 mm. long and brownish yellow in colour and have become branching, having branches on the stem and a rosetted top. Besides the horns there are some black hairs and needle-like black spines on the head. All the spines are now bigger than in the previous stage ; the sub-median spines have all a rosetted top ; the supra-spiracular and infra-spiracular spines are now distinctly branching, the supra-spiracular spines showing a somewhat rosetted top and the sub-infra-spiracular spines have grown into long fleshy spines without any branches, but there are hairs on them. The spines on prothorax have grown bigger, one being branching and those on the first abdominal segment are also bigger and branching. The branches of the spines do not possess at the top, the black needle-like hairs noticed in the previous stage except in a few cases. The colour of the larva is green with the spines, only the brown parts and the brown spines on the meta-thorax and third and seventh abdominal segments and the stripes between them, noticed in the previous stage, are black ; the median spine on seventh abdominal segment is brownish. The dorsal vessel is more distinct.

Fourth instar.—Just after the third moult the larva measures about 9 mm. and grows to about 14 mm. before it is ready for the next moult. The head is black with a big triangular white patch above the clypeus, a small greenish patch above each mandible and the posterior part behind the horns green. The horns are yellow and about 2 mm. long. Besides the horns there are white unbranched spines on the head. The sub-median, supra and infra-spiracular spines have all got rosetted tops ; the sub-infra-spiracular spines are now branching. The colour is green. The black parts and spines on the back noted in the previous stage are still black, but the median spine on seventh abdominal segment is yellowish green. A broad yellow mid-dorsal stripe is very distinct between meta-thorax and seventh abdominal segment. Faint white oblique markings are perceptible in the lateral regions.

Fifth instar.—After the fourth moult the length is about 15 mm. and increases to about 30 mm. when the larva is full-grown. The head is black with the same white patch above the clypeus and other white markings above the mandibles, at the bases of the horns and also at the sides. The horns are about 5 mm. long, brownish yellow with the basal half and the branches of the rosette having a blackish tinge ; besides the horns there are green un-

branched spines on the head. The colour is deep green, the venter and the lateral regions being covered with a white powder; there are faint oblique markings on the sides. The mid-dorsal stripe is broad and yellow and prominent between prothorax and the eighth abdominal segment. The spines on the prothorax are small, four only showing branches. All the other spines on the body are now with rosetted tops and are also green in colour with the exception of the sub-median spines on meta-thorax and third and seventh abdominal segments which are black. Only a faint trace is left of the black stripes in the sub-median regions.

Pupa.—When full-grown the larva usually leaves the food-plant and pupates elsewhere, for example, on the walls of houses, trunks of trees, etc. It sometimes pupates on the stem of the food-plant but hardly ever on the leaf. Many caterpillars were watched on castor growing in the Insectary compound; none of them pupated on the food-plants; the pupæ would be found on the sides of a wire gauze cage which happened to stand in the midst of the castor plants; occasionally one would be found on the trunks of trees close by or on the wall of the Insectary which was at some distance from the castor plants. The caterpillar spins a thin network of silk on the surface on which it will pupate and sits head downwards with the anal prolegs held in the fibres of the network. It rests in this position for about a day or sometimes two days in the cold weather, and then turns into a pupa by casting off the larval skin. At this time the colour of the larva loses most of the green and turns greyish. In some the green colour disappears entirely, giving rise to a dull greyish brown. The mode of shedding this skin is practically the same as noticed in the case of the Rice Leaf Caterpillar, *Melanitis ismene.*

The pupa (Plate II, fig. 8) is about 20 mm. long and about 7 mm. across the thoracic region. There are two protuberances on the anterior end and ridges on the back of thorax and anterior part of abdomen. The hind end is provided with numerous small circinate hairs which are held in the fibres of the silken network and hold the pupa hanging in air head downwards. The colour is green. A V-shaped black mark appears at about the middle of the back in the advanced stage. Before the emer-

gence of the butterfly the colour turns greyish and the wing-regions become dark grey.

Imago.—The butterfly (Plate II, figs. 9 & 10) emerges by bursting the pupa-case along the regions of the antennæ and the mid-dorsal thoracic line, the fissure on the back extending sideways and then along the margins of wing-cases to some extent. It hangs on the empty pupa-case until the wings expand and all the limbs harden properly. At this time a quantity of reddish liquid excreta is voided. The butterfly is found flying rather slowly and gracefully among castor plants or any vegetation which grows somewhat densely. It occasionally sits on a leaf slowly folding up and unfolding the wings or holding them down flat for a short time.

DANAIS CHRYSIPPUS, LINN.

THE AK BUTTERFLY.

(PLATE III. FIGS. 5—9)

[Bingham, Fauna of India, Butterflies, Vol. I, 1905, p. 11.]

Distribution.—A widespread species throughout our limits (the Indian region) and found in Southern Europe, Syria, over a great part of the Ethiopian Region, through Arabia, Persia and Afghanistan. Eastwards it extends to China and through the Malayan sub-region to Sulu and the Celebes. (Bingham).

This is a common butterfly, orange-brown in colour with black and white markings, found flying gracefully any time of the day. It occurs throughout the year. The caterpillars are common on the Ak or Akanda plants, *Calotropis gigantea,* the milkweed, on the leaves of which they feed. In September 1909 they occurred in large numbers in a plot of *Asclepias semi-lunata* grown at Pusa for the Fibre Expert's experiment.

The period of the life-cycle observed in ordinary temperature is as follows :—

—	(1)	(2)
Egg laid	11 a.m., 6th May.	
Egg hatched	morning, 9th ,,	5th July.
The larva pupated	19th ,,	15th ,,
The butterfly emerged ..	27th ,,	22nd ,,

The egg.—The egg is cylindrical, tapering abruptly at the top, and with the sides ribbed longitudinally. It measures about $1\frac{1}{2}$ mm. in height and a little more than 1 mm. in breadth. It is set vertically on the surface of the leaf. The colour is creamy white. The

We remark that it is almost always the case in this chapter and the next that $\mathsf{Gen}(1^n)$ chooses $k \leftarrow \{0,1\}^n$ uniformly at random.

3.2.1 The B[illegible] Definition of Security

There [illegible] several ways of defining security for [illegible] encryp[illegible] differences relate to the assumed power [illegible] ve[illegible] the most basic notion [illegible] – [illegible] weak form of ciphertext-only attack wh[illegible] sees only a *single* ciphertext — and consider stronger [illegible] security later in the chapter.

Motivating the definition. As discussed in Chapter 1, any definition of security consists of two distinct components: a specification of the [illegible] power of the adversary, and a description of what constitutes a "break" of the scheme. We begin our definitional treatment by considering the case of an eavesdropping adversary who observes the encryption of a single message [illegible] equivalently, a [illegible] that it wishes to "crack". [illegible] rather weak class of adversaries, but is exactly the type of adversary that was considered in the previous [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible]. Of course, [illegible] in the previous section [illegible] [illegible] [illegible] [illegible] computationally bounded and [illegible] running [illegible]

Although we have [illegible] [illegible] about the adversary's capabilities (i.e., [illegible] [illegible] [illegible] we make no assumptions [illegible] crucial for obtaining [illegible] to predict all possible [illegible] that can be carried [illegible] adversaries.

Defining the "break" [illegible] [illegible] [illegible] [illegible] [illegible] this issue at length in [illegible] therefore just recall that [illegible] should be unable to learn any partial information [illegible] ciphertext. The definition of semantic security [illegible] notion and was the first definition [illegible] [illegible] Unfortunately, the definition of semantic security is complex [illegible] work with. Fortunately, there is an equivalent definition in terms of indistinguishability which is much simpler. Since the [illegible] we can work with the simpler definition of indistinguishability while being convinced that the security guarantees we obtain are those we expect from semantic security. (See Section 3.2.2 for further discussion [illegible])

The definition of indistinguishability we give here is [illegible] identical to the alternative definition of perfect secrecy given in Definition [illegible] (This serves as further motivation that the definition of indistinguishability is a "good" one.) Recall that Definition 2.4 considers an experiment [illegible]

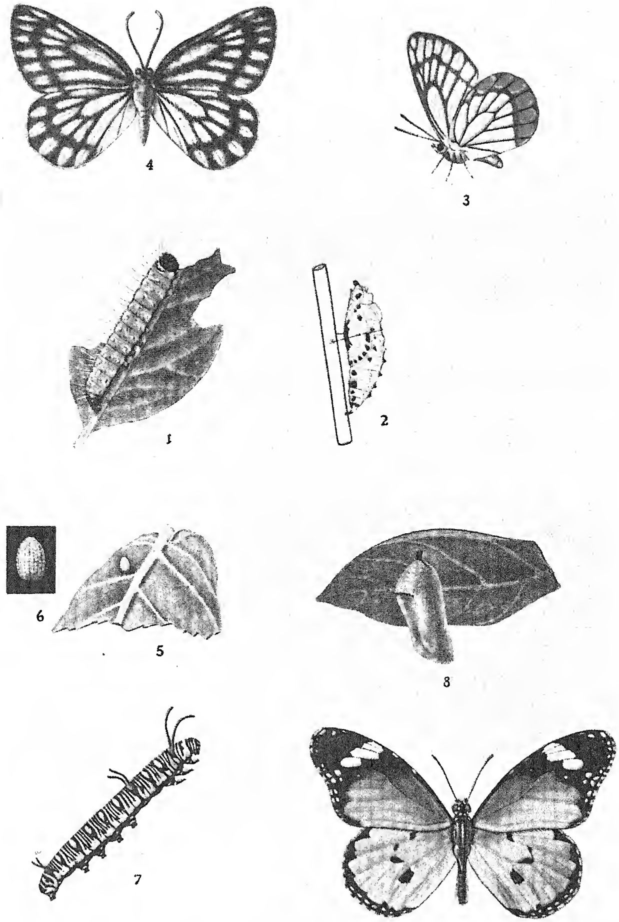
EXPLANATION OF PLATE III.

Fig. 1. Deilas eucharis, larva.
2. " pupa.
3. } " butterfly.
4. }
5. Danais chrysippus, the Ak butterfly, egg on leaf.
6. " egg magnified.
7. " larva.
8. " pupa.
9. " butterfly

EXPLANATION OF PLATE III.

Fig. 1. *Delias eucharis*, larva.
" 2. " " pupa.
" 3.} " " butterfly.
" 4.}
" 5. *Danais chrysippus*, the Ak butterfly, egg on leaf.
" 6. " " egg magnified.
" 7. " " larva.
" 8. " " pupa.
" 9. " " butterfly

PLATE III.



[redacted]

eggs are deposited singly on the leaves of the plant. The leaves chosen are not always tender. One egg was observed to be laid at 11 A.M. on 6th May.

The caterpillar.—The young larva hatches out of the egg by gnawing a hole at one side near the top. After emergence it eats the deserted egg-shell entirely and then proceeds to feed on tender leaves.

The young larva is cylindrical in shape and is about $2\frac{1}{4}$ mm. long. The head is black, shiny and slightly larger than prothorax. The colour of body is slightly greyish pale yellow. The prothorax bears two black spots at the sides. There is a small brown tubercle at each subdorsal region of mesothorax and of second and eighth abdominal segments. These later on develop into the long filaments characteristic of this caterpillar. The larva possesses a black anal shield and five pairs of equally developed prolegs. In the course of about a day faint yellow bands are perceptible under the lens on the back and the brown tubercles develop into small spines. Just before the first moult the larva is about 5 mm. in length and yellowish brown in colour. The spines are red. After the first moult, the larva is about 6 mm. long. The characteristic banded appearance with dark velvety brown and yellow bands of the grown-up larva is evident. The head is black and shiny and has developed one white semi-circular marking enclosing the white clypeus and a white spot above the clypeus. The black shiny spots are present on whitish prothorax. The spines or filaments on mesothorax and second and eighth abdominal segments are bigger and black. The ventral surface is deep red brown, almost dark. After the second moult the larva is about 9 mm. long. The head has developed one more semi-circular white marking on the front. The brown bands on the segments have become black. The filaments have become longer than in previous stage, the mesothoracic pair being more so than the two abdominal pairs.

After the third moult the larva is about 18 mm. long. Filaments have become still longer and the colouration noted in the previous stage is more developed.

After the fourth moult, the larva is about 25 mm. In this stage it becomes full-grown measuring about 40 mm. The meso-thoracic filaments are about 8 mm. long, while those on second and eighth abdominal segments are about 5 mm. long. The bases of all the filaments are red. The legs are black and the spiracular regions yellow. The general colour is dark grey; but the cater-pillar is banded in appearance with the characteristic black and yellow bands. On each segment there are five narrow black bands, the second and third enclosing a yellow band which is divided in the median region and extends up to about the sub-median parts.

The caterpillars pass through four larval moults and pupate at the fifth. The table below shows the periods of the instars of two :—

Larva hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult ; pupated.
(1) 9th May (2) 19th ,,	11th May 21st ,,	13th May 24th ,,	15th May 26th ,,	17th May 28th ,,	19th May 31st ,,

A record was kept of the weight gained by the second larva and of the excrement passed. The excrement was not allowed to dry before weighing.

May 19 : The caterpillar hatched. Weighed ·04 grain and measured $2\frac{1}{2}$ mm. in length.

,, 21 First moult ; length 6 mm. Weight ·1 grain. Weight of excrement passed from the time of hatching up to this moult ·13 grain.

,, 24 Second moult ; length 8 mm. Weight ·18 grain. Weight of excrement passed between first and second moults ·3 grain.

,, 26 Third moult ; length 12 mm. Weight ·63 grain. Weight of excrement passed between second and third moults ·3 grain.

,, 27 Weight 2·3 grains. Excrement passed in the last 24 hours ·15 grain.

,, 28 Fourth moult ; length 25 mm. Weight 3·4 grains. Excrement in the last 24 hours 1·1 grain.

,, 29 Length 33 mm. Weight 9·8 grains. Excrement in the last 24 hours 20·6 grains.

,, 30 Length 38 mm. Weight 12·1 grains. Excrement in the past 24 hours 15·7 grains.

,, 31 Pupated. Excrement up to the time of pupation 2·7 grains. Weight of pupa 9·96 grains. Weight of last larval skin ·13 grain.

June 1 : Pupa 9·79 grains.
,, 2 ,, 9·7 ,,
,, 4 ,, 9·5 ,,
,, 5 ,, 9·46 ,,
,, 6 The butterfly emerged; a male, which weighed 4 grains. The empty pupa-case weighed 1 grain.

Similar records of the development of caterpillars will be found in Vol. II, Nos. 5 & 6 of this series of Memoirs. More complete records about the growth of caterpillars showing food consumed, weight gained and excrement passed will be found at pp. 33-35 of Vol. IV, No. 1.

The pupa.—When the caterpillar is full-grown and ready to pupate, it forms a thin padding by applying silk on the under-surface of a leaf or somewhere on the stem. Then the hooks on the anal prolegs are well entangled and held in the fibres of the padding and the larva hangs in the same manner as the pupating caterpillar of *Melanites ismene.* (Plate I, fig. 5). In the course of the day it transforms into a pupa by casting off the larval skin. The pupa too hangs in the same way as that of *Melanites ismene.*

Excluding the cremaster the pupa measures about 18 mm. in length, about 8 mm. across at the golden ridge, about 6½ mm. across the middle, and about 5½ mm. near the head end. It is light green or pinkish in colour with golden spots on the head (lower) end and a black bordered golden line or ridge in the posterior part on the back encircling about half the circumference.

The butterfly.—The butterfly emerges by bursting the lower end of the pupa and hangs on the empty pupa-case. When it emerges the wings are crumpled and small and the abdomen is very thick and short. The wings quickly expand and harden and the abdomen lengthens and becomes thinner. In the course of about an hour the butterfly is able to fly.

Enemy.—The caterpillars are extensively parasitised by a Tachinid fly. The caterpillar pupates with the parasitic maggot or maggots in its body. When the maggots are full-grown they come out and drop on the ground and pupate there. Out of 227 caterpillars and pupæ collected, 134 or about 59% were found parasitised.

PIERIS BRASSICÆ, LINN.

THE CABBAGE WHITE.

(PLATE IV).

[Bingham, Fauna of India, Butterflies, Vol. II, 1907, p. 170.]

Distribution.—Europe, Northern and Central Asia, the Himalayas from Chitral to Bhutan up to 10,000 feet (Bingham). Major H. C. Tytler records it from the Naga Hills (Jl. Bomb. Nat. Hist. Soc., Vol. XXI, p. 591). He remarks:—"Rather scarce; two males and three females taken at Kohima in February, August and October." It descends about 100 miles of the Himalayas in the plains.

Broods.—The Cabbage White Butterfly, *Pieris brassicæ*, occurs within about 100 miles of the Himalayas in Eastern and North Bengal, Bihar, the United Provinces and the Punjab. Recently (1912) it has been reported to occur on cabbage seedlings far down in Lower Bengal at Midnapur and this too in November; no specimens were sent and the report has to be accepted with caution. It appears at Pusa late in January or early in February. Thus in 1911 it was for the first time found flying over cabbage and cauliflower in the Insectary compound on the 6th February and eggs were found the same afternoon. In 1912 it was observed for the first time on 13th February. Three or four generations occur consecutively, mainly on cabbage and cauliflower and then the insect disappears by May or even earlier and reappears towards the close of the next cold weather. It is believed that the butterflies migrate from the hills, but there is no actual proof of such migration. However it is certain that they stop breeding in the plains in the hot weather. In 1912 and 1913 large numbers of caterpillars were reared in order to see if any of them would æstivate in the pupal

stage, the caterpillars being collected as long as they were found in the fields. All became butterflies, which were given opportunities for laying eggs and breeding but they died without laying any eggs, although the conditions were practically the same in which they bred in confinement earlier in the season.

Food-plants and damage.—In the neighbourhood of Pusa these butterfly caterpillars cause serious damage to cabbage, cauliflower, lettuce and similar plants. There is a reference to *Pieris brassicæ* under the name of *Mancipium nepalensis*, Grey, in the Indian Museum Notes, Vol. II, pp. 45-46, where a report is mentioned as made from Umballa in January 1890, stating that caterpillars of this butterfly attacked gram, *toria* (Rye), linseed, sugarcane and garden vegetables, such as radishes. An attempt was made to feed the caterpillars with all these plants, but they would not even touch gram, linseed and sugarcane and died. All cruciferous plants they ate without distinction. It would seem, therefore, that the statements in the Indian Museum Notes are based on mistaken observations. At Pusa the caterpillars were for the first time found on Cape Gooseberry to which they had strayed, probably for pupating and which they never ate.

Life-history.—The period of the life-cycle in warm weather is about four weeks from egg to butterfly and about two days more to eggs again. If the weather be cold this period is longer. The period in warm temperature is shown below :—

Egg laid.	Egg hatched.	Larva pupated.	Butterfly emerged.	Periods in days.
31st March	4th April	21st April	28th April	4 + 17 + 7 = 28
1st April	5th ,,	20th ,,	29th ,,	4 + 15 + 9 = 28
4th ,,	8th ,,	24th ,,	3rd May	4 + 16 + 9 = 29
13th ,,	17th ,,	3rd May	10th ,,	4 + 16 + 7 = 27

The egg.—The butterflies being diurnal in habit, eggs are laid only during the day. The eggs are deposited in clusters and on

cabbage and cauliflower, usually on the undersurfaces of leaves near the apex. The clusters are very prominent, being big yellow patches on green leaves, but they are hardly visible to a man walking among the plants and the leaves have to be turned up before they come into view. It was not actually determined how many eggs each butterfly is capable of laying. In the Insectary the maximum number of eggs laid in the same cluster was 74; but from the fields, clusters containing up to 203 eggs have been collected. Therefore it can be taken that each butterfly is capable of laying not less than 200 eggs and probably lays many more. Each egg is flask-shaped and measures a little more than 1 mm. in height and about $\frac{1}{2}$ mm. across the thickest part and tapers upwards; the sides are ribbed in regular order longitudinally; the colour is orange yellow, but it becomes dim about a day before hatching and just before hatching it turns rather grey and there is a faint black spot near the top marking the head of the embryo within the shell. The eggs stand vertically on the surface of the leaf and are neatly arranged in the cluster, but so that they do not quite touch one another. The period of the egg-stage is, as shown in the table of the life-cycle, about four days when it is warm. It is longer in a cold temperature; thus eggs laid on 27th February 1912, hatched on 3rd March, after five days and some eggs laid on 8th February 1911, hatched on the 17th February, after nine days.

The larva.—When ready to hatch out from the egg the fully developed embryo or the young larva gnaws a big hole from within at the upper part of the shell and emerges through it. The empty egg-shell is white. The eggs in the same cluster hatch almost at the same time. This is natural, as they are deposited almost at the same time. After emergence the young caterpillars eat the empty egg-shells as their first meal, consuming them wholly and also nibbling a portion of the surface where they stand. Not infrequently that portion of the leaf is bitten through, a big hole being produced in its place. The young larva is about 2 mm. long and cylindrical in shape. The head is big, black and shiny and the segments of the body are indistinct. The colour is uniform pale-

yellow. All over the body there are small white hairs. The larva possesses the usual three pairs of thoracic legs and five pairs of prolegs. The body of the just-hatched larva is pale-yellow. In the course of a day it becomes slightly greenish and covered with many black points which are actually small tubercles surmounted with hairs and take some time to turn black. The prothoracic shield also takes some time to turn black. It is divided at the middle. The head develops a white space in front, of the shape of an inverted V which becomes yellowish later on and more prominent at successive moults. After the first moult the larva almost exactly resembles the full-grown caterpillar in colour and appearance, the colour being yellowish-green. The full-grown larva is cylindrical and is about 40 mm. long, the average daily growth of the larva being about $2\frac{1}{2}$ mm. The posterior two-thirds of each lobe of the head is greenish-grey and has got a large black spot laterally appearing like a big black eye. The front is black and encloses a pale-yellow triangular mark with its apex turned upwards. The head is covered with small hairs. The body is yellowish-green and is covered with small as well as long white hairs. There is a green narrow median line and a big dark patch consisting of numerous small dark spots, above the spiracle of each segment. This region shows a network of black markings upon a yellowish-green background. From a little above the spiracles downwards, the colour is not so green. This region is also covered with hairs arising from very small numerous black or dark-brown tubercles. The larva passes through four or five moults. Out of four larvæ noticed, two moulted four times and two five times. Before each moult the larva rests for some time ; the segments of the body become very marked and the head becomes a little detached from the prothorax which seems to be prolonged into a sort of neck. The skin bursts in the thoracic region along the mid-dorsal line and the larva walks out as from a case. In all the moults except the last one at which pupation takes place, the moults of the head and the skin are cast separately. The cast skins are never eaten and the larvæ being of a gregarious habit, many skins will be found at the same place.

The periods of the instars and the number of moults are shown below :—

	Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	Butterfly emerged.
1.	20th Mar.	25th Mar.	29th Mar.	1st April	5th April (pupated.)		15th April
2.	,,	,,	28th ,,	31st Mar.	4th April (pupated.)		,,
3.	,,	,,	,,	30th ,,	1st April.	5th April (pupated)	14th ,,
4.	5th April.	9th April.	12th April.	15th April.	20th April.	23rd April (pupated)	1st May

The pupa.—Throughout the larval life the caterpillars are gregarious in habit, living, moving and feeding in company. Many will be found collected together and feeding side by side. As long as food is available they hardly show any inclination to disperse; consequently, those which hatch on the same plant continue to remain on it until forced to leave it by scarcity of food. When, however, they are full-fed and full-grown they part company and scatter in different directions. Not a single caterpillar or pupa will be found where a few days ago literally hundreds might have been feeding. They sometimes travel over great distances in search of proper places where they can safely pass the pupal stage, high and shady places being generally preferred. In the Insectary compound they have been observed to travel a distance of about fifty feet from the food-plants and then to climb upon a big tree and pupate on the undersurfaces of leaves and to crawl up the Insectary wall and pupate under the cornice. It is evident that pupæ can hardly be found in pairs or several together.

The caterpillar exudes a white silk from the spinneret and applies it on the surface where it means to pupate in the form of a netting. It then entangles the hooks on the anal prolegs in the fibres of this netting and passes a silken girdle over the first abdominal segment fixing the two ends of this girdle at two points in the netting. More silk is found to be accumulated at these three points of attachment than at other places in the netting. The head of

the pupating larva and of the subsequent pupa is turned upwards. Having thus secured itself in position the larva rests for about a day, becoming much shortened in length. It then turns into a pupa by casting off the larval skin.

The pupa measures about 22 to 24 mm. in length and 5 mm. across the wing region. There is a small snout at the head end and the hind end is tapering from the third abdominal segment. In the mid-dorsal region there is a longitudinal ridge on the three thoracic segments; the ridge disappears on the first and second abdominal segments and reappears at the posterior part of the third abdominal segment and runs up to the anal segment; it rises high like a pyramid on the meso-thorax. At the spiracular region on each side on the second, third and fourth abdominal segments there is a ridge which protrudes into a spine on the third abdominal segment. The girdle passes over the first abdominal segment. When newly formed the pupa is pale yellow; then it changes to green and finally to grey; it is speckled with black all over the surface. The snout is yellow and the mid-dorsal ridge too is spotted yellow.

The imago.—The head end of the pupa bursts along the regions of the antennæ and the mid-dorsal line of the thorax. The butterfly struggles through this opening with soft crumpled wings and hangs from the empty pupa-case until the wings expand and all the appendages harden. At this time it voids a quantity of liquid excrement which is pinkish or reddish in colour. Sometimes the liquid excrement is voided inside the pupa-case just before the butterfly emerges; in such cases the hind part of the pupa looks deep pink. Sometimes again it is voided similarly when the butterfly has come out partly from the pupa-case. The butterfly measures 2½ inches across the wings. The males and females are of about the same size but the abdomen of the female is slightly thicker. The body is black or dark grey. The upper surfaces of the wings are white except the outer corners of the forewings which are black; in addition to these black corners the female has two black patches in the middle of the forewings and she can be at once distinguished by them. On

the underside the colouring of both the wings is the same in both sexes; the forewings are white with two black patches in the middle, the portions of the corners corresponding to the black above being yellow; the hind wings are yellow. The butterflies are diurnal in habit and literally swarms of them will be found flying sportively over cabbage and cauliflower plants. When they sit the wings are held folded above the back. They too indulge in the same kind of courtship as has been noticed in the case of the Tur Hair Streak (*Catochrysops cnejus*). They couple end to end and may mate on the day of emergence. In copulation the male is rather passive and seems to hang down inertly. Mating was observed to last for $1\frac{1}{2}$ to 2 hours. At night the butterflies are inactive and hang on some place motionless; in the cage they hardly stirred even when light was introduced and they were actually touched. In confinement they do not live long; they lived for not more than four or five days in the Insectary.

Enemies.—The caterpillars are parasitised by a Dipterous (Tachinid) and a Hymenopterous parasite. But they increase so rapidly that these parasites have hardly any effect as an appreciable check.

Preventive and remedial measures.—It is not easy to prevent the butterflies from laying eggs. The simplest remedy is to examine the plants at intervals of about three days and destroy the egg-clusters which can be easily done by rubbing them with finger. If any egg-cluster escapes notice, the young larvæ cannot fail to attract attention on the nibbled leaf which is to be removed and buried with the caterpillars. On account of the gregarious nature of the caterpillars large numbers of them can be disposed of without any appreciable damage to the plants. The examination of the plants too, is a simple work capable of being carried out easily by a boy and does not involve much time. This remedy is particularly feasible in the case of garden crops, such as cabbage, cauliflower, etc.

DELIAS EUCHARIS, DR.

(PLATE III, Figs. 1-4).

[Bingham, Fauna of India, Butterflies, Vol. II, 1907, p. 141.]

Distribution.—The Himalayas up to 7,000 feet; the whole of Continental India except the desert tracts; Ceylon.

This is one of the commonest butterflies of the plains. The caterpillars feed on the misletoe (*Loranthus*) growing on various trees, such as mango, sissoo (*Dalbergia sissoo*), gular (*Ficus glomerata*), etc., and are very largely found specially about March when warm weather sets in after winter. The butterflies are notably flower-frequenting in habit and have been observed at Pusa and at Rangpur to visit mustard flowers in large numbers in November and December.

The life-cycle was observed in winter and again in March and April, the following being the periods of the stages :—

Eggs, apparently freshly laid, collected, 8th March.	29th Nov.
Eggs hatched, 11th-12th March.	4th Dec.
The caterpillars pupated, 1st April.	21st Jany.
The butterflies emerged, 10th April.	11th Feby.

The egg.—The eggs are deposited usually on the upper-surfaces of tender leaves of the misletoe, one to several eggs being laid on the same leaf. Up to sixty-nine eggs have been found in a cluster on a single leaf. Even when thus deposited in a cluster unlike most butterfly eggs, they are scattered irregularly. They stand vertically on the surface on one end which is broad, or lie on one side. The egg is about $1\frac{1}{2}$ mm. high and about 1 mm. in diameter at the base. It is round, flask-shaped, being narrow at the top which, however, does not end in a point but is concave.

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[Bingham, Fauna of India, Butterflies, Vol. II, 1907, p. 141.]

Distribution.—The Himalayas up to 7,000 feet; the whole of Continental India except the desert tracts; Ceylon.

This is one of the commonest butterflies of the plains. The caterpillars feed on the misletoe (*Loranthus*) growing on various trees, such as mango, sissoo (*Dalbergia sissoo*), gular (*Ficus glomerata*), etc., and are very largely found specially about March when warm weather sets in after winter. The butterflies are notably flower-frequenting in habit and have been observed at Pusa and at Rangpur to visit mustard flowers in large numbers in November and December.

The life-cycle was observed in winter and again in March and April, the following being the periods of the stages :—

Eggs, apparently freshly laid, collected, 8th March.	29th Nov.
Eggs hatched, 11th-12th March.	4th Dec.
The caterpillars pupated, 1st April.	21st Jany.
The butterflies emerged, 10th April.	11th Feby.

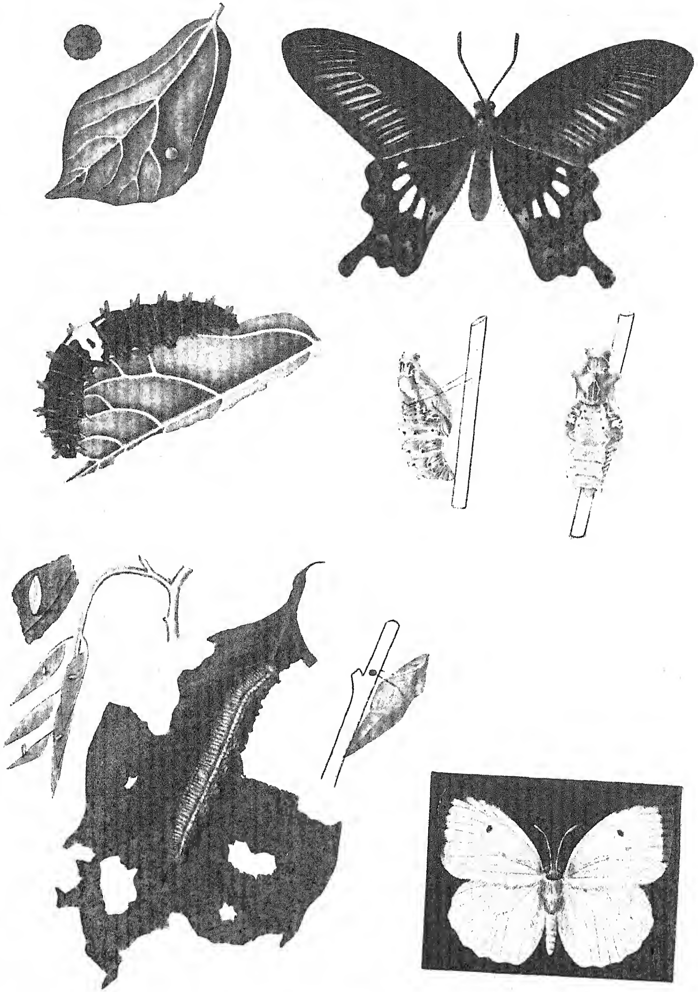
The egg.—The eggs are deposited usually on the upper-surfaces of tender leaves of the misletoe, one to several eggs being laid on the same leaf. Up to sixty-nine eggs have been found in a cluster on a single leaf. Even when thus deposited in a cluster unlike most butterfly eggs, they are scattered irregularly. They stand vertically on the surface on one end which is broad, or lie on one side. The egg is about $1\frac{1}{2}$ mm. high and about 1 mm. in diameter at the base. It is round, flask-shaped, being narrow at the top which, however, does not end in a point but is concave.

There are longitudinal ribs on the surface. The upper ends of the ribs run beyond and project to some extent beyond the rim of the concavity. The colour is yellow.

The larva.—The young larva hatches out of the egg through a hole gnawed near the top. It then eats the white empty shell either partly or wholly and then begins to feed on the leaves. Throughout the larval period it throws out silk profusely. The caterpillars are gregarious in habit, several being found sitting side by side on a leaf and eating it from the edge inwards. The young larva is about 2 mm. long and cylindrical in shape. The head is black, shiny and the body yellow. There are yellowish hairs scattered on the segments and the usual five pairs of prolegs are present, all being equally developed. In appearance and shape the larva hardly undergoes any change but develops a brown or rather copperish brown colour as it grows. When full-grown, it measures about 32 mm. in length and about 5 mm. across. The head is dull black. There is a narrow black thoracic shield. The body is uniform copperish brown and the anal segment black. There are long white hairs scattered on the segments. The bases of a row of hairs in the sub-median region and of another row in the sub-spiracular region are white tubercles and these make the larva look somewhat white-spotted.

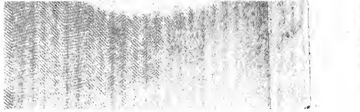
The pupa.—The caterpillars pupate as usual by attaching the hind end to a previously prepared silken padding. Besides, there is the usual girdle passing over the posterior part of the first and sides of the second abdominal segment. The head of the pupating larva and of the subsequent pupa is turned upwards. The pupa is similar in shape and appearance to the pupa of the Cabbage White butterfly, *Pieris brassicæ.* It is, however, yellow in colour and bears a series of black tubercular processes. The butterflies emerge from the pupa in the same way as *Pieris brassicæ.*

PLATE V.



EXPLANATION OF PLATE V.

Fig. 1. *Papilio aristolochiæ*, egg as laid on leaf.
,, 2. ,, ,, egg magnified.
,, 3. ,, ,, larva.
,, 4.}
,, 5.} ,, ,, pupa.
,, 6. ,, ,, butterfly.
,, 7. *Catopsilia pyranthe*, eggs as laid on tender leaves.
,, 8. ,, ,, a single egg magnified.
,, 9. ,, ,, larva feeding on leaf.
,, 10. ,, ,, pupa.
,, 11. ,, ,, butterfly.



CATOPSILIA PYRANTHE, LINN.

(PLATE V, Figs. 7-11).

[Swinhoe, Lepidoptera Indica, Vol. VII, 1905-10, p. 90.]

Distribution.—Throughout India; Assam, Burma, Tenasserim, not ascending the Himalayas to above 7,000 feet. It extends to China on the east and as far as Australia southwards (Bingham). Ceylon, Siam, Annam, Malay Peninsula, Sumatra, Java, Borneo, Formosa, Hainan (Swinhoe).

This is a common butterfly the larvæ of which feed probably on all species of *Cassia*. They have been reared on *Cassia occidentalis, C. fistula, C. sophera, C. sophera var. purpurea and C. tora.* The caterpillars are extremely common on these weeds specially in the rains. They have also been collected in April. It is not known in what state they pass the winter. Cycles were observed in June and September and the periods of the stages were as follows:—

—	1	2
Eggs laid ...	25th September	9-15 to 9-24 A.M., 7th June.
Eggs hatched	27th September	5-7 A.M., 9th June.
The caterpillars pupated ...	6th October	20th June.
The butterflies emerged ...	13th to 14th October	27th June.

The egg.—The butterflies can be observed flying over the plants and depositing eggs in the morning or any time of the day. One morning in June a butterfly was observed laying eggs on a *Cassia fistula* tree about eight feet high. A brood of caterpillars had been feeding on it and it had been stripped of about half of the old leaves. Many new shoots had grown, on most of which the leaves did not yet open. The butterfly flew over and round the tree occasionally sitting on a leaf or on leaf-stalk and depositing one egg every time.

The abdomen was curved down so that the hind end touched the surface and when it was raised after about two or three seconds, the white egg was there; at the same time the butterfly took to wing. In this way twenty-four eggs were deposited in the course of nine minutes from 9-15 to 9-24 A.M., and then the butterfly flew away. Of these twenty-four eggs, two were deposited on the stem of tender shoots, one on the stalk of a tender leaf, one on the undersurface of an old leaf, and the remainder on tender leaves.

The eggs are deposited singly on either surfaces of leaves or their edges and occasionally on leaf-stalks and tender twigs. The egg stands vertically on the surface. It measures about $1\frac{1}{2}$ mm. in length and about $\frac{1}{2}$ mm. in diameter at the middle. It is tubular or cigar-shaped with tapering ends. The entire surface is ribbed longitudinally. The colour is white and hardly undergoes any change before hatching.

The larva.—The young caterpillar hatches out of the egg through a hole gnawed on one side. After emerging it turns round and eats the empty shell either entirely or only one side of it and then strays about and begins feeding on the leaves, nibbling small holes in their surface.

The newly-hatched caterpillar is about 2 mm. long and cylindrical in shape. The head is bigger in diameter than the body which tapers very slightly towards the hind end. The segments are not very distinct and bear longish hairs. The colour is uniform white, but it soon changes to pale yellow and acquires a greenish tinge as soon as green food is taken. There are the usual five pairs of prolegs and under a high power lens the rudiments of the transverse folds on the segments so characteristic of the grown-up larva, are observable. The larva passes through four larval moults and pupates at the fifth. The periods of the instars of two caterpillars which hatched on the same day are given below :—

Hatched, morning,	27th September.
First moult, afternoon,	28th ,,
Second ,, ,,	30th ,,
Third ,, ,,	1st October.
Fourth ,, ,,	3rd ,,
Fifth ,, pupated,	6th ,,

When the larva was resting before casting off the first moult, small drops of a clear liquid were found collected at the tips of the hairs. After the first moult it grows to 5 mm. in length. The head is yellow and the body green. All over the head and body minute tubercles appear surmounted with minute back hairs.

After the second moult the length is about 7 mm. and there is no distinct change.

After the third moult the larva is 13 mm. long. The head is greenish-yellow and body green. The segments are not at all distinct, but the whole of the back is a series of narrow transverse folds. As already noted these folds are apparent in earlier stages and have now become quite distinct. The small black tubercles are arranged on the folds. A white stripe appears in the lateral regions.

After the fourth moult the larva is about 23 mm. long. A black edging appears on the upper margin of the lateral white stripe. Really this edging is formed by black tubercles which are also bigger than those on the back.

When full-grown, the larva is about 40 mm. long and about 5 mm. broad. The shape is about cylindrical being slightly compressed dorso-ventrally. The colour and appearance are as have been described above. Between the white stripe and its black edging on the upper margin a narrow yellow line is apparent.

The pupa.—When full-grown and about to pupate most of the caterpillars leave the food-plants and pupate elsewhere. The larva spins out silk and applies it to leaf or stem where it means to pupate. The anal prolegs are held in the fibres of this padding and a girdle of silk is passed over the back at the meta-thoracic region, the two ends of the girdle being fixed to a point on the padding. The larva then rests in a ventrally curved posture in the same manner as the lemon butterfly (*Papilio*) caterpillar, Pl. VI, fig. 7, and transforms into a pupa by casting off the larval skin. The head end of the pupa is usually turned upwards; it may, however, be at the same level as the hind end or even point downwards.

The pupa is about 24 mm. long and compressed laterally in the wing region. The hind part is tapering and the head end rather abruptly tapers into a small pointed snout. The colour is green like the leaf of the food-plant. There is a small ridge on each side running from the snout to the hind end and also one in the mid-dorsal region on prothorax. These ridges are yellow and the lateral ones look like stripes. The pupa is fastened to the silken padding by hooks at the hind end and is held in position by the girdle.

Before emergence of the butterfly the pupa turns yellowish chalky white and the parts of the butterfly are visible When the butterfly emerges the head of the pupa breaks away, the fissure running along the antennæ; at the same time the thoracic ridge opens and this opening runs up to the meta-thorax and then extends on each side between meta-thorax and the first abdominal segment. The two halves of the pronotum also break, but do not fall off entirely. After emergence the butterfly hangs on the empty pupa-case until the wings expand and all the limbs harden. At this time it usually voids a quantity of liquid excrement which on drying turns into a chalky white powder.

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LEMON CATERPILLARS.

EXPLANATION OF PLATE VI.

The Lemon Caterpillars.

Papilio demoleus and *P. pammon.*

Fig. 1. Eggs as laid on leaf.

„ 2.} „ 3.} *P. demoleus*, young larvæ in different stages of growth.

„ 4.} „ 5.} *P. pammon* „ „ „

„ 6. *P. demoleus*, full-grown larva.

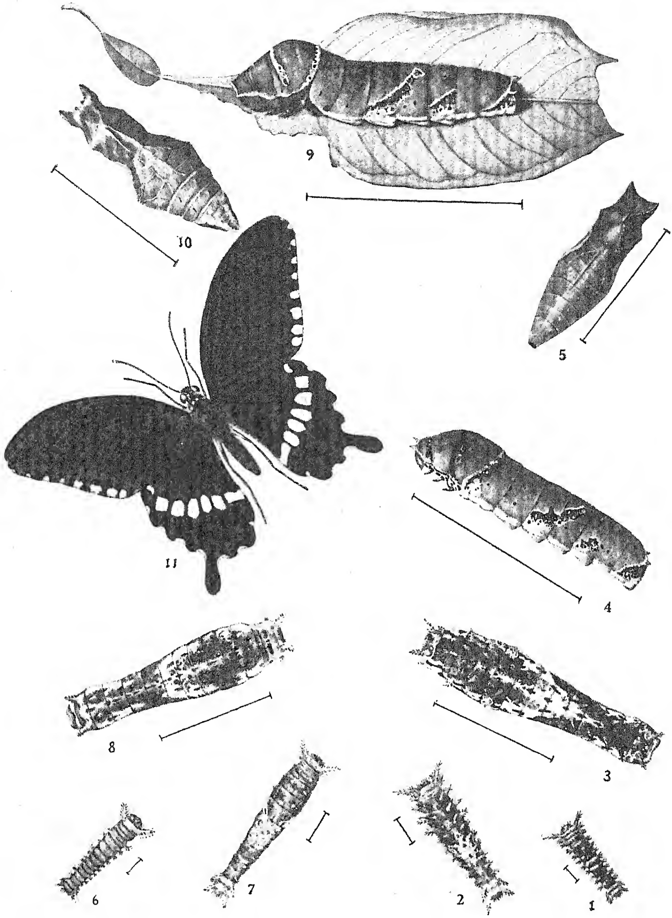
„ 7. *P. pammon*, pupating larva.

„ 8. *P. demoleus*, pupa.

„ 9.} „ 10.} „ butterfly.

This Plate was originally prepared to illustrate the life-history of a lepidopterous insect in "Fasaler Poka" a vernacular (Bengali) book on insects and insect pests.

PLATE VII.



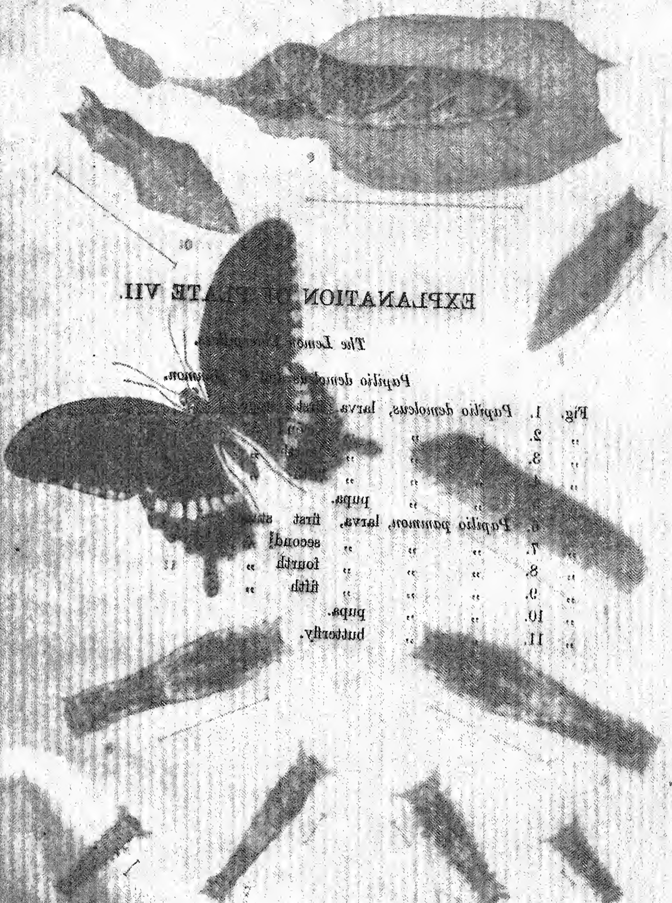
THE LEMON CATERPILLARS.

EXPLANATION OF PLATE VII.

The Lemon Caterpillars.

Papilio demoleus and *P. pammon.*

Fig.	1.	*Papilio demoleus,*	larva,	first	stage.
,,	2.	,,	,,	,, second	,,
,,	3.	,,	,,	,, fourth	,,
,,	4.	,,	,,	,, fifth	,,
,,	5.	,,	,,	pupa.	
,,	6.	*Papilio pammon,*	larva,	first	stage.
,,	7.	,,	,,	,, second	,,
,,	8.	,,	,,	,, fourth	,,
,,	9.	,,	,,	,, fifth	,,
,,	10.	,,	,,	pupa.	
,,	11.	,,	,,	butterfly.	



THE LEMON CATERPILLARS

THE LEMON CATERPILLARS.

(PLATES VI & VII.)

Papilio demoleus, Linn.

[Bingham, Fauna of India, Butt. Vol. II, 1907, p. 39.]

AND

Papilio pammon, Linn.

[Bingham, *P. polytes*, Fauna of India, Butt. Vol. II, 1907, p. 61.]

Distribution—P. demoleus.—Kashmir to Ceylon; Assam to Upper Burma, up to a moderate elevation; extending to Persia and eastwards to China and Formosa. A local form *malayanus* distinguishable by the width of the median cream coloured band on the hindwing, which Bingham considers as a race, occurs in Lower Burma, Tenasserim and Malay Peninsula. Many specimens from Assam to Lower Burma are intermediate as regards the width of this band (Bingham).

P. pammon is a polymorphic form. The female varies slightly but is fairly constant throughout its range; (Bingham notes two aberrations of the male from Southern India); the female generally with two forms, in Southern India and Ceylon with three, strikingly different in appearance.

It occurs almost throughout our limits, including the Andamans and Nicobars; extending to Siam and the Malayan sub-region to Sumatra (Bingham).

Relation between the two.—These two butterflies live in close relationship in all their stages, partaking of the same food. In their younger stages they are liable to be confused, as the distinguishing characteristics are not very marked. Eggs of both are laid promiscuously on the same plant; also the larvæ live and

feed side by side. Butterflies also will be found fluttering about in company over the food-plants. The relation between these two butterflies seems to be more intimate than is supposed when two insects of the same genus live on the same food-plant. One morning at about 7-30 A.M. while watching some of these butterflies among lemon and orange trees in the vegetable garden at Pusa, the following observation was made. They were all in a state of continual flutter, paying visits to plant after plant and branch after branch of the same plant as if reconnoitring the whole of it, sometimes getting into the dense part of the foliage and again coming out and flying round the plant. Occasionally one would sit on a tender twig, but only for a moment and again took to wing.

One *P. pammon*, a female, was noticed sitting on a branch of a lemon tree with her wings more or less extended. After a few moments a male *pammon* came across her, approached her, and fluttered round advancing the hind end of his body towards that of the female trying to copulate. The female seemed to be quite passive and dropped on to and caught hold of a twig, a few inches below. The male flew away.

After a few moments a *demoleus* male came and made vigorous overtures, which the female *pammon* not only did not reject, but, on the other hand, seemed to like. She approached the hind end to that of the advanced abdomen of the *demoleus* male; the hind ends met several times but actual copulation did not take place. The female seemed to be in a very nervous state; she then dropped down to a branch below and after a few seconds to the ground and continued to sit for about six minutes on a dry twig on which she happened to alight. The male flew away. Then she flew to a lower branch of the same tree where she remained sitting until after about seven minutes another *pammon* came flying to her, she took to wing and both began to flutter about in company for about 15 or 20 seconds; then the female came and sat with the wings extended on a branch of a neighbouring plum tree and continued to do so for about fifteen minutes when the observations were

discontinued. She was the only one to behave in this manner, all others were continually fluttering about. Evidently she had newly emerged and had not yet mated. From this it appeared that it may not be impossible that *P. pammon* and *P. demoleus* may mate, although they have not been actually observed to do so.

Proportion in which P. demoleus and P. pammon occur.

Of the two butterflies, *P. demoleus* is very common, the other occurring in small number. Between 4th and 22nd April, sixty-five caterpillars were collected on orange trees and of them only two were *P. pammon*, the rest being *P. demoleus*. Again about the same time, between 4th and 25th April, 245 eggs were collected from the same trees. Out of them, 138 *P. demoleus* hatched, while only eleven were *P. pammon* and the rest were parasitised. Out of seventy-nine caterpillars picked from two young lemon trees on 25th May, all proved to be *P. demoleus*.

Distinguishing characters in the earlier stages of P. demoleus and P. pammon.

Eggs.—The egg of *P. pammon* is slightly bigger than that of *P. demoleus*. Four *P. demoleus* eggs measured 1·15, 1·09, 1·06 and 1·01 mm. in diameter. Two *P. pammon* eggs measured 1·25 and 1·2 mm. in diameter.

Larvæ, first instar (Plate VII, figs. 1 & 6).—The newly hatched caterpillars are very easily distinguishable. *P. pammon* is slightly bigger and less hairy and less spiny in appearance than *P. demoleus* which has comparatively big spines all over the body, *P. pammon* having rather tubercles surmounted with hairs in place of spines on all segments except prothorax, seventh and eighth abdominal and first anal segments. *P. pammon* is yellow with brownish sides while *P. demoleus* is dark brown with a whitish spot in the middle of the body, this spot in *P. pammon* being much fainter.

Second-fourth instars (Plate VII, figs. 2, 3 & 7, 8).—*P. demoleus* retains the spines while the spines in *P. pammon* either disappear or are reduced to small tubercles except those on pro-

thorax and eighth abdominal and first anal segments, so that this latter has a more or less smooth appearance. The colour in both is dark brown; *P. demoleus* may be almost black; *P. pammon* has a greenish tinge. The V-shaped white marking in the middle of the body is present in both. Compared with *P. demoleus* the meta-thoracic region of *P. pammon* is much thicker.

Fifth or last instar (Plate VII, figs. 4 & 9).—The two larvæ resemble each other more than in previous instars; both are green and spineless. In rare cases *P. demoleus* may have spines as noted later on in the first variety of the larva (p. 47) of this butterfly. The prothoracic spines or horns are reduced in both, but are bigger in *P. demoleus* than in *P. pammon*. The principal distinguishing features are the markings on the composite segment formed by the union of meta-thorax and first abdominal segment. In *P. pammon* (Plate VII, fig. 9) the region above the legs on the thoracic segments is a velvety dark grey; this grey colour goes up along the posterior edge of the composite segment and meets on the back and is followed by black on the anterior part of the second abdominal segment. The anterior edge of the composite segment has a yellowish or brownish collar which extends on each side up to about the supra-spiracular region (where its extremity is ocellated) and does not go down further to meet the dark grey above the region of the legs; the extremities are turned a little posteriorly off from the inter-segmental region between meso-thorax and meta-thorax; there is no black band preceding this collar. In *P. demoleus* (Plate VII, fig. 4) there is not such a broad dark grey space above the region of the legs on the thoracic segments. The two edges of the composite segment, *viz.*, the anterior and the posterior are respectively preceded and followed by broad black bands which go down straight to the lateral regions, the marking on the anterior edge being thus quite different from that in *P. pammon*.

Pupæ (Plate VII, figs. 5 & 10).—The protuberances (about 2 mm. in length) on the head of the pupa of *P. pammon* are

bigger and therefore the indentation deeper than in *P. demoleus* in which the protuberances (about $\frac{1}{2}$ mm.) are never big and the indentation not deep. *P. pammon* pupa has a much broader appearance about the third abdominal segment, the broadest part in both pupæ. Also it may be noted that no brown *P. pammon* pupa has been noticed.

Food-plants and damage.—Both *P. demoleus* and *P. pammon* are destructive to young Citrus trees as they defoliate them. They eat young leaves of grown-up trees, but the damage thus caused hardly ever proves very injurious to them. *P. demoleus* has been found on Bael (*Ægle Marmelos*) and *Psoralea corylifolia* and probably feeds on other *Rutaceæ*. *P. pammon* too will most probably be found on all these plants.

Broods.—*Papilio demoleus* occurs in the plains throughout the year and as there is no regular succession of broods all the stages may be found at any time. Most probably this too is the case with *P. pammon*. As will appear from the tables, the periods of the life-cycle are enormously lengthened in the cold weather. It is probable that in cold places, *e.g.*, the hill stations, there is a period of hibernation which is passed in the pupa state. A pupating larva collected in Shillong (5,500 ft.) on 21st October, pupated on 22nd October and the pupa lived through the whole of the winter. It, however, did not emerge and was found dead on 13th April.

Life-history.—The life-histories of *P. demoleus* and *P. pammon* are similar, and in a way may be considered to have been mixed up. The egg of both is round, only that part coming in contact with the substratum being flat. The egg-shell is tough and membranous and smooth. The colour is pale-yellow, becoming brownish later on with a darker brown spot at the top and ultimately turning grey before hatching. The eggs of both are laid together promiscuously, singly on leaves or leafstalks of tender shoots but mostly on leaves, either at their apices or margins or anywhere on either surface, the majority being on the under-

surface ; thus out of 30 eggs collected at random, only four were on the upper-surfaces and the rest on the undersurfaces of tender leaves. From one to ten or twelve eggs may be found on the same shoot, each leaf having from one to three or four eggs according to its size.

The young larva gnaws a hole in the shell and comes out through it and eats the empty shell. It then begins to eat young leaves biting them from the edges and feeds on leaves throughout the larval state. In the first stage the larvæ of the two butterflies are different in appearance. In the second instar their appearance begins to get similar and gets more and more so in successive instars. In the earlier stages the larvæ live on the upper-surfaces of leaves and while they rest there, present a remarkable similarity to droppings of birds. In the last instar both become green and as they grow quickly and to a large size in this instar, they leave the leaves and usually sit on stems, where they are not easily distinguishable on account of the similarity of the colour of the body to that of the stem. Again most have broad markings on the body, grey or brown in colour and mixed with white ; besides, the meta-thorax and the first abdominal segment unite in both to form a big bulging segment which has broad brown or dark grey edgings at the anterior and posterior parts; the anterior edging has ocellated markings. The larva is in the habit of sitting with the head and the first two thoracic segments drawn in. This part is highly tapering as will appear from figures 4 & 9, Pl. VII. In the resting attitude the larva presents an appearance much like that of a snake, the anterior part from the bulging composite segment forming the head. This is more apparent in *P. pammon* than in the other.

The larvæ of both throw out a red Y-shaped soft process (fig. 3, Pl. VI) from behind the head when disturbed, at the same time emitting a strong smell which savours to a certain extent of the smell of *Artabotry sodoratissimus* flowers (Kantali-champa, Bengali). The tips of the arms of the process are also vibrated. If the back

is touched the head is raised and bent over the back in the attempt to remove the cause of the disturbance with the process.

The larvæ of both pass through four larval moults and pupate at the fifth. Some, however, may have only four moults in all. Before moulting the larva spins out and applies a very thin layer of silk in the form of a netting on the surface of the leaf and sits and rests on it with the hooks on the prolegs held in the fibres of the netting. The whole period of the rest extending over several hours, seems to be passed in the attempt to extricate the new head. The skin is detached behind the head, first of all in the dorsal region, thus exposing partly the head and the anterior part of the prothorax and then gradually in the ventral region. It is then shed by a sort of a peristaltic movement of the muscles of the body, as the larva gradually moves forward. The shedding is facilitated by the backward pull exerted on the skin owing to the entanglement of the hooks on the prolegs in the silken netting. The skin retains the general shape partly as the larva moves out of it as from a case. While the larva moves forward the old head-moult is still on the head sticking over the mouthparts and is got rid of by being rubbed on the surface of the leaf. The larva sits quietly for some time, usually with the head and thorax slightly raised up in air and then turns round and eats the skin. During the period of the rest before moulting and specially just before casting off the skin, the larva is quite helpless but is held in position by the fastening previously secured of the prolegs to the silken netting.

Pupation takes place on the plant, generally on the stem and occasionally on the leaf. When full-grown many caterpillars leave the food-plant and pupate elsewhere and may walk long distances before doing so. Hence very few pupæ are actually found on the plant which nourishes a large number of caterpillars. The larva prepares a silken padding. The anal prolegs are held tightly in the fibres and a silken girdle is passed over the meta-thoracic region, the ends of the girdle being fixed to two points in the padding. In order to make these three points of attachment secure, more silk

is found to be applied at these places. When pupating on a twig silk is applied all round it, and at the anal point of attachment specially, a thick ring of silk is formed. Thus securing itself the larva rests as shown in fig. 7, Plate VI, with the head bent towards the ventral surface. At this time the body is much contracted. Before the actual rest commences the larva voids a large quantity of soft excreta. The head of the pupating larva and necessarily that of the pupa is always turned upwards. Ordinarily after about a day of rest the last larval skin is cast and the pupa appears.

The pupæ of *P. demoleus* are of three different colours: (1) green, (2) yellowish-brown or dry straw, (3) dark grey with black markings looking like a roughly notched rotten piece of dry wood. The pupæ of *P. pammon* are: (1) green, or (2) bluish-green with grey, wood-brown and black patches all over. The different colours are not indicative of sex in either species.

Emergence of the butterfly.—The colour of the green pupæ remains green till several hours before emergence of the imago (pupæ are green in evening but are found changed the next morning and the butterflies emerge within an hour or so) when it turns paler and then brown. Before emergence of the imago all its parts and the stripes and spots on the body and wings are clearly visible. In the brown and dark grey pupæ the changes are not so visible. The empty pupa-case of the green pupæ is dirty white and thinner than that of brown and dark grey pupæ in which the pupa-cases are brown and dark grey respectively.

The pupa-case first of all bursts transversely at the intersegmental suture between head and prothorax on the dorsal surface. The head is thus freed and the butterfly emerges by further efforts with movements of legs and body. These efforts burst the mesothorax in the mid-dorsal region and extend the fissure behind the head along the antennæ on each side up to about the end of the wing region. The butterfly is free from the pupa-case within less than half a minute. While it struggles to extricate itself it

voids a quantity of dirty brown liquid excrement inside the pupa-case. After coming out it sits quietly hanging on the empty pupa-case. Unless the wings hang downwards they cannot expand properly. The following is the record of observation on the emergence of a *P. demoleus* female butterfly. It holds good for *P. pammon* as well:—The butterfly emerged at 6-55 A.M. While it was emerging the little finger of the left hand was presented and it held on to it. The wings were not crumpled but short and very soft. The legs were properly developed and were quite functional, the butterfly being able to walk quickly. The wings began to increase in size and attained the full size at 7-5 A.M. but were soft yet. They began to harden from the base. At times the butterfly tried to raise them but they bent down beyond the stiff portion. They became stiff up to the tip at 7-30 A.M. Still the butterfly was not able to fly. It was occasionally frightened by sweeping the right hand past it in order to make it fly away; it would only shift its position a little or straighten itself up. It began to unfold the wings flat and close them over the back at intervals, evidently to bring the connected muscles into play. It was not able to fly until these muscles were in proper working order. At 7-45 A.M. it flew but alighted on the ground at a distance of about five yards. A finger was presented and it was easily induced to crawl on to it. It sat on the finger and was not disturbed. It took to wing and sailed away in the air at 8-10 A.M.

The expanding and stiffening of the wings is effected by a greenish fluid which runs from the body into the veins. The decrease in size of the body is dinstinctly perceptible as also the swelling of the veins and their change of colour to a greenish tinge. The costal vein of the left hind wing of this butterfly was injured; a greenish fluid collected at the injured point into a small greenish gall; the vein beyond the injured point did not develop and the portion of the wing served by this vein or rather a little more became crumpled and remained so.

In confinement it is not easy to get butterflies to lay eggs. They mate easily if sufficient room is available for them to fly freely.

One female and one male *P. demoleus* emerged on the morning of 23rd April. They were liberated in a big cage at 8 A.M. and at 10 A.M. were found coupling. Both were sitting on wire-gauze side of the cage, the head of the female being downwards. They continued to sit at the same place till 11-5 A.M. when they separated and the male flew away ; the female continued to sit there for some time. Similar observations were made on several pairs. They were supplied with diluted honey and had access to a living lemon plant. Several such couples reared in the Insectary, were tried but no eggs obtained. The butterflies also did not live for more than two days. On one occasion eggs were obtained from *P. pammon*.

One pair of *P. demoleus* butterflies in copulation was captured in the morning of 11th June and liberated in a big cage where they had access to a living orange plant. The male died on 12th. Between 13th and 14th the female laid twenty-one eggs, eleven on the stem, three on the upper-surfaces and seven on the undersurfaces of leaves, and died in the afternoon of 14th. The eggs hatched between 16th and 17th.

Enemies.—The eggs of both these butterflies are parasitised to a very great extent, by three kinds of minute Hymenopterous insects. Out of 245 eggs collected between 4th and 25th April, 96 or about 39% were found to be destroyed by these insects. Out of 65 caterpillars collected about the same time, only two (*P. demoleus*) were parasitised by a Tachinid fly. The caterpillars pupated with the parasites in their body and the maggots came out of the pupæ, four from one and six from the other, and pupated outside. In nature they drop on to the ground and pupate there. The majority of the caterpillars were collected before they passed through the fourth moult, *i.e.*, before they became green, and many of the eggs too were collected in

the early stage. It is possible that some more might have been parasitised if left in the natural conditions.

Further details in the life-history of each are given below :—

Papilio demoleus.

Life-cycle :

Egg collected.	Larva hatched.	Larva pupated.	Butterfly emerged.	Duration in days.
11th December	19th December	15th January	7th March	8 + 27 + 52 = 87
,,	,,	28th ,,	24th ,,	8 + 40 + 56 = 104
22nd April	25th April	10th May	19th May	3 + 15 + 9 = 27
3rd July	5th July	16th July	24th July	3 + 11 + 8 = 22

Larval moults :

Larva hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.
4th April	7th April	9th April	11th April	13th April	17th April, pupated.
25th ,,	27th ,,	29th ,,	1st May	5th May	10th May, ,,
5th July	7th July	9th July	11th July	16th July, pupated.	

The following is the record of the growth of a larva which hatched on 4th April :—

4th April 1913 : *Young larva.*—$2\frac{1}{2}$ mm. long when fully stretched in locomotion. Not exactly but about cylindrical in shape. Head smaller than thorax which is the thickest part ; body becomes very gradually narrower towards middle of abdomen and again somewhat thicker towards the anal segments. Head and prothorax brownish-yellow ; dorsal regions of third and fourth and to a less extent of the fifth abdominal segments yellowish-white ; abdominal segment eighth and the first anal segment brownish-yellow ; rest of body brown or dark brown.

All segments except the head and second anal segment are provided with small spines ; hence the larva looks spiny. Each spine consists of a small fleshy tapering protuberance, surmounted by a white hair but black at the

tip and having in addition hairs on the sides. The arrangement of the spines on each side is as follows :—

—	Pro-thorax.	Meso-thorax.	Meta-thorax.	Abdominal segments.								Anal segments.	
				1st	2nd	3rd	4th	5th	6th	7th	8th	1st	2nd
Sub-median ..	1	1	1	1	1	1	1	1	1	1	1	1	1
Dorso-lateral ..	1	1	1										
Supra-spiracular	..	..	..	1	1	1	1	1	1	1	1	1	
Spiracular ..	1	1	1										
Infra-spiracular..	1	1	1	1	1	1	1	1	1	1	1	1	

The sub-median spines are situated in the sub-dorsal line on the edge of the median region; those on the second anal segment are merely small tubercles surmounted with hairs. The dorso-lateral spines are situated just below the sub-median spines; those on prothorax are the biggest of all the spines on the body. The supra-spiracular spines are situated just above the line of spiracles; those on first abdominal segment are of the form of real spines, the others being practically rosettes of hairs. The spiracular spines are in a line with the spiracles; those on meso-thorax and meta-thorax are like tubercles surmounted with hairs. In the infra-spiracular position, *i.e.*, below the spiracles, the segments have really small rosette-shaped tufts of hairs.

The spines are of the same colour as the segments; but the spines on third and fourth abdominal segments are white, like their dorsal regions.

6th April.—It seems the larva is going to moult. Two faint whitish interrupted stripes are visible under the lens below the sub-median row of spines on each side.

7th April: 1st moult.—The larva is about 4 mm. long, the appearance is as spiny as before, the same spines being there, only the spiracular spines on meso-thorax and meta-thorax have become shorter and blunt. The shape too is about the same, the thoracic region being thicker than the rest of the body. The head is brown with a faint white patch above the clypeus. The prothorax is brownish-yellow with the spines. Only the dorsal regions of the eighth abdominal and first anal segments are brownish-yellow with the spines on them. The white patch on third, fourth and fifth abdominal segments is prominent; laterally it is found to have encroached a little on the second abdominal segment. The general colour is brown as before but a little darker. Two faint interrupted whitish stripes are found below the sub-median row of spines on each side.

9th April : 2nd moult.—The larva is about 7 mm. long. There is not much change in appearance. The head is about as big or slightly bigger than the prothorax, dark brown in colour and has a whitish spot above the clypeus with yellowish markings round it. The pronotum with the spines on it is brownish-yellow and has developed some white markings which are interruptedly continued in the lateral region on to the meso-thorax. White markings connected with the white patch on third, fourth and fifth abdominal segments, extend on to the second abdominal segment on each side. White markings have appeared on the eighth abdominal segment below the spines. The stripes below the sub-median spines have become fainter. Short tubercles in the form of smaller spines have appeared one on each side of the median line on the three thoracic and the first abdominal segments and also in place of supra-spiracular rosettes on seventh and eighth abdominal segments. The spiracular spines on meso-thorax and meta-thorax have become still smaller. The spines are of the same colour as the segments, those on third and fourth abdominal segments being white as before; the spiracular spine on prothorax is white.

10th April.—The larva has grown rapidly from 7 mm. to 11 mm. in the past 24 hours. The region about the meta-thorax and first abdominal segment is the thickest part being about 3 mm. in diameter, from which the body tapers on either side ; the hind part is about 2 mm. or a little less in diameter.

11th April : 3rd moult.—It has grown to about 12 mm. in length, but has undergone hardly any change in shape. The general colour is black. The prothoracic dorso-lateral spines which look like horns, have become thicker and bigger. On each side of the median line tubercles are found in all spine-bearing segments except third to sixth abdominal segments; those on prothorax are reduced so much in size as to be practically non-existent ; those on the meta-thorax are the biggest. The white markings on prothorax have extended in the spiracular regions up to meta-thorax, the spiracular spines on all these segments being white. The white patch in the middle of the body extends in the dorsal region either interruptedly or in varying breadth from second to seventh abdominal segments and on each side from second to fourth abdominal segments. There is a prominent white patch on each side on seventh, eighth and first anal segments, speckled with black. The spines are brown except the thoracic spiracular ones, as already noted, those on third and fourth abdominal segments and the supra-spiracular ones on eighth abdominal and first anal segments.

12th April.—The general colour is a very dark grey.

13th April : 4th moult.—The larva has undergone a complete change in appearance and colour. It has grown to about 23 mm. in length. The meta-thoracic region which is the thickest part measures about 6 mm. across and the hind part of the body about $4\frac{1}{2}$ mm. across. Head dull yellowish-brown, together

with legs and prolegs. All spines have disappeared except the prothoracic dorso-lateral ones which look like a pair of horns and the sub-median ones on first anal segment ; these too have become much shorter and hairless and are brown in colour. The head is deflexed and is not visible when looked at from a posterior direction. The anterior part of prothorax has an edging of grey which is marked with thin black markings and continues up to the meso-thorax above the region of the legs. The meta-thorax and the first abdominal segments have united and merged into apparently one segment bordered on the anterior edge by interrupted brown which is preceded by a broad grey band and on the posterior edge by a brown band which is followed by black in the anterior part of the second abdominal segment ; this black band usually remains telescoped under the preceding segment and thus hidden under the brown band. Throughout the length of the body there is a whitish stripe just above the bases of the legs ; continuous with this stripe there is a brown broad marking on the fourth abdominal segment running obliquely upward on to the fifth abdominal segment ; there is a similar somewhat oblique marking or patch in the spiracular region on the sixth abdominal segment. The anterior parts of abdominal segments third to seventh, have black spots which are not, however, usually visible as these parts remain telescoped under the preceding segments. In place of the sub-median spines abdominal segments fifth to eighth have very small brown or yellow tubercles or rather spots. The posterior part of the first anal segment is dark grey. Above the prolegs, the second anal segment has a black lunar marking. General colour yellowish-green. Ventrally whitish.

14*th April.*—This morning the colour has become green.

15*th April.*—About 40 mm. when extended in motion; about 7 mm. across meta-thorax, and about 5 mm. across abdomen. From the meta-thorax the body is very slightly and gradually tapering posteriorly. Anteriorly too, it tapers rather abruptly. Colour green. Spots on seventh and eighth abdominal segments have practically disappeared.

16*th April.*—Began to rest before pupating.

17*th April.*—Pupated. Colour of head, thorax and wing regions of pupa very light green ; of rest of body light yellow.

18th *April.*—The pupa is dry straw colour.

25*th April.*—Male butterfly emerged.

The larvæ in the last instar show a great variation in colour and appearance. This, however, is not indicative of sex. This has been proved by rearing a large number of the larvæ separately. The majority correspond to the description given above

which may be taken as that of the typical larva in the last instar. In addition the following variations were noticed:—

(1) In some the spines on the seventh and eighth abdominal segments do not disappear; the other spines disappear as described above, but in their places small tubercles are found.

(2) In many the general colour is slightly greenish yellow or yellow instead of being green. Before pupation however much of the yellow fades and proportionately the green is apparent. In these yellow larvæ the grey portions are prominently black.

(3) In many there is a rich suffusion of black. The thoracic segments including the anterior part of the composite segment are suffused with black or are almost black, only the spiracular regions being yellow. The anterior parts of second and third and the dorsal regions of seventh and eighth abdominal segments and almost the whole of the anal segments are suffused with black.

(4) In some the small round spots in the sub-median regions on sixth, seventh and eighth abdominal segments do not disappear. Occasionally any one of these segments may be without these spots, the others having them. These spots are either brown or partly blue and partly brown.

(5) In some, the broad oblique marking on fourth and fifth abdominal segments is broken up into (*a*) a small patch on the fourth below the spiracle and detached from the whitish stripe above the region of the legs, and (*b*) a pair of small round spots on the fifth, one in supra-spiracular and the other in the sub-median position. The marking on the sixth abdominal segment too is reduced to a small patch below the spiracle.

(6) In some again there is no marking or spot in any of the abdominal segments, the larvæ looking uniform velvety green. In fact in these larvæ the only markings present are the edgings of the composite segment and the grey bands preceding and following it.

Pupa.—The pupa is 31 mm. long by 10 mm. broad. In shape it is about the same as that of *P. pammon* described below, showing the same constrictions and protuberances, with the following points of difference :—

(1) The protuberances on the head are much smaller, being about $\frac{1}{2}$ mm. or a little more in length ; hence the indentation between them is much shallower.

(2) The prothoracic constriction is about 6 mm. across ; the meso-thoracic protuberant portion is $7\frac{3}{4}$ mm. across ; the meta-thoracic constriction is about $7\frac{3}{4}$ mm. across ; the broadest part about the third abdominal segment is 10 mm. across. The meta-thoracic constriction is much less apparent than in *pammon* pupa ; hence the breadth at the third abdominal segment is not apparently so great as in *pammon* pupa, which has a much broader appearance.

Papilio pammon.

Life-cycle :

Egg laid.	Egg hatched.	Larva pupated.	Butterfly emerged.	Duration in days.
(1)	10th April	23rd April	1st May	3 + 13 + 8 = 24
(2)	27th ,,	14th May	23rd ,,	3 + 17 + 9 = 29
(3)	25th August	5th Sept.	21st Sept.	3 + 16 + 11 = 30
(4) 5th March.	12th March	12th April	22nd April	7 + 31 + 10 = 48

The eggs of (1), (2) and (3) were collected from outside. A very large number of eggs were collected at this time and the egg-stage was found to be about three days. (4) was observed in another year which was much colder.

Larval moults :

Larva hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.
12th March	22nd March	26th March	1st April	12th April, pupated.	
23rd April	25th April	29th April	1st May	5th May	11th May, pupated.
27th ,,	29th ,,	2nd May	5th ,,	7th ,,	13th ,, ,,
27th ,,	29th ,,	1st ,,	3rd ,,	6th ,,	14th ,, ,,

The following is the record of larval development :—

10th April : Egg hatched.—Young larva several hours old, about 3 mm. long. Head and prothorax and meta-thorax are the thickest parts ; meso-thorax is slightly thinner ; beyond the meta-thorax the body tapers slightly

becoming slightly thicker again at the anal region. The same number of spines or tubercles are present as in the *P. demoleus* larva but except those on prothorax and eighth abdominal and first anal segments, the other spines are distinctly smaller so as to be considered as minute tubercles bearing hairs ; also the body is not so hairy as in the other larva but it has small tubercles on each side of median line between the sub-median spines on the three thoracic and the first abdominal segments ; these develop in a later (third) instar in the other larva. *Pammon* larva has a distinctly less hairy and less spiny apppearance. It differs entirely in colouration. Its general colour is yellow, with the two sides dirty brownish ; thus at a casual glance its entire dorsal region looks yellow. The tubercles on prothorax, fourth and eighth abdominal and first anal segments are pale yellow ; those on other segments are brownish-yellow.

12*th April :* 1*st moult.*—Length about 6 mm. Across meta-thorax about 1½ mm. Across hind part about 1 mm. Head brown with blackish markings, smaller than prothorax. Segments not clearly distinguishable, specially meso-thorax and meta-thorax and the first abdominal segment. All spines except the horn-looking prothoracic dorso-lateral ones and those on seventh and eighth abdominal and first anal segments have become reduced in size and seem to be very small tubercles only. General colour yellow with the sides darker. There are somewhat indistinct broad white markings on the sides of third abdominal segment which go up posteriorly and seem to unite or approach on the back of the next segment. The sides of seventh and eighth abdominal segments and anterior part of first anal segment are white.

14*th April :* 2*nd moult.*—The larva measures 9 mm. in length, across meta-thorax about 2 mm., and across abdomen about 1¼ mm. There is not much change in appearance. Head and prothorax yellow. General colour of rest of body dull dark brown. The whites on the sides of third abdominal segment have become more prominent and have extended to the posterior part of the preceding segment and approach each other on the back of the succeeding segment. In continuation of this white patch, the dorsal region of the succeeding segments up to the seventh abdominal is yellow. The sides of seventh abdominal segment white with a brown spot ; sides and dorsal region (where there is a brown spot) of eighth abdominal segment white with the spines ; anterior region of first anal segment white.

16*th April :* 3*rd moult.*—Length about 19 mm. Breadth about 4½ mm. across meta-thoracic segment which is the thickest part from which the body tapers both ways ; about 3 mm. across middle of abdomen and again thicker about eighth abdominal segment which measures about 3½ mm. across. General colour dark brown. Head brown, shiny, with whitish markings on

sides, deflexed and not visible when looked at from the direction of the back. Prothorax brownish-yellow with the horns yellow ; from the base of the horns a broad white stripe in the spiracular region up to meta-thorax. Broad white markings from about the spiracular regions of the second abdominal segment, going obliquely upwards over the third abdominal, coalesce on the back of the fourth abdominal segment and extend up to the back of the fifth abdominal segment. Above the spiracle, the posterior $\frac{3}{4}$ of the sides of seventh and whole sides of eighth abdominal segment white, as also the anterior part of first anal segment in continuation. No other proper spine except the prothoracic horn-like dorso-lateral and the sub-median ones on eighth abdominal and first anal segments, the other spines are reduced to tubercles small or big ; those on third and fourth abdominal segments are reduced to a very minute size.

18*th April: 4th moult*.—Larva moulted at 10 A.M. About $5\frac{1}{2}$ mm. across the composite segment formed by the union of meta-thorax and first abdominal segment, which is the thickest part from which the body tapers slightly and gradually towards the hind end and more towards the head. In general appearance the larva resembles the *P. demoleus* larva in this stage. Head dull dirty green with a slightly yellowish tinge. Colour of body green, ventrally greenish white, like green covered with a white powder. Behind the head the anterior part of prothorax has a brownish marking which is continuous with the big broad velvety dark brown patch above the legs ; these velvety brown patches from each side meet each other over the back at the posterior part of the composite segment where it is bordered anteriorly by a brown collar. The anterior edge of the composite segment has a somewhat raised ridge looking like a collar which has black markings on it. In this larva this collar goes down about as far as the supra-spiracular area on each side and does not meet the velvety brown patch. (In the *P. demoleus* larvæ this collar meets the patches, which are either brown or dark or black, on each side). From the second abdominal up to the anal segments there is a fleshy fold which is white and looks like a stripe just above the base of the prolegs. In continuation with this stripe or a little detached from it, a broad brown marking on the fourth abdominal segment goes obliquely upwards up to the posterior part of the sub-median region of the fifth abdominal segment. There is a similar marking or patch on the sixth abdominal segment only up to the spiracular region ; some larvæ do not show this marking. The posterior corner of the lateral region of the eighth abdominal segment, the whole of the lateral and posterior part of first anal and the entire anal segment, are whitish with numerous black patches.

The prothoracic horns are much reduced in size and only look like wedge-shaped protuberances and are yellow in colour. The spines on eighth

abdominal segment are very much reduced in size and are like minute tubercles; those on the first anal segment are also reduced but still look like spines or cerci. There is no other spine or tubercle on the body. On fifth abdominal segment two small round blue spots with brown rim are present but included in the oblique brown patch, one in sub-median and the other in supra-spiracular region. There is a pair of similar spots in the sub-median region of sixth abdominal segment. The dark-brown velvety space above the thoracic legs is quite large and is a distinguishing character.

20th April.—Length 40 mm., 10 mm. across composite segment; 6 mm. across sixth abdominal segment, 4½ mm. across prothorax. Head brownish-yellow, about 4 mm. from side to side. Colour of body green. Anterior edge of prothorax grey-brown. The region of the horns forms a raised rim, yellow in colour. The velvety space above the legs, on meso-thorax and composite segment is grey-brown. This grey-brown patch on either side goes upwards and meets on the back at the posterior part of composite segment followed by black in the anterior part of second abdominal segment; this black may ordinarily remain telescoped under the composite segment and be invisible. The anterior part of no other segment shows black markings or spots. The other markings on the body are there as described after fourth moult. The tubercles on seventh and eighth abdominal segments have completely disappeared.

21st April.—Length 45 mm. when extended in locomotion; across composite segment 11½ mm.; across prothorax 5 mm.; across anal segment 6 mm. The *P. demoleus* larvæ, too, attain to this size but the composite segment (meta-thorax and first abdominal segment) is a little less broad being about 9 mm. or 9½ mm. across. Hence, the anterior end of *P. pammon* larva in the full-grown state looks more tapering. At each extremity of the yellow collar on anterior edge of composite segment there is a big black ocellated spot looking like an eye.

22nd April.—Larva pupating.

23rd April.—Pupa.

The pupa.—The pupa measures 31 mm. × 12 mm. The shape is peculiar or which a reference should be made to the illustration. The head has a pair of protuberances one on each side, about 2 mm. long, the median region being deeply indented. The prothoracic region is somewhat constricted (6 mm. across). The anterior part of meso-thorax is thicker (8 mm. across), shows a protuberance on each side laterally and a third somewhat pyramidal one in the median region. The meta-thoracic region is again constricted (7 mm. across); then the body becomes broader, being broadest at the third abdominal segment measuring 12 mm. across and then tapers towards the hind end which measures about 2 mm. across. The measurements of all

pupæ of both *demoleus* and *pammon* are taken from the direction of the back; the length is measured from the indentation on the head to the hind end and the breadth across the broadest part, *viz.*, the third abdominal segment.

In colour the pupæ are green. Some pupæ may be of a mottled colour; the general colour is light bluish-green with a suffusion of grey, wood-brown and small patches of black here and there. The green pupæ have a brown spot in each sub-median region on meta-thorax. The motley pupa has a tubercle in each sub-median region on abdominal segments fourth, fifth and sixth. The girdle of all pupæ (*demoleus* and *pammon*) passes over the meta-thorax. The parts of the pupa are rigid and not capable of any kind of movement except the three inter-segmental regions between the fourth and seventh abdominal segments, which allow of movements in all directions. Usually when the pupa is disturbed it moves these segments laterally and a short hissing sound is produced. The *P. demoleus* pupa too produces a similar sound but much less distinct.

1*st May*.—Butterfly emerged, male.

PAPILIO ARISTOLOCHIÆ, FABR.

(Plate V, figs. 1—6).

[Bingham, Fauna of India, Butterflies, Vol. II, 1907, p. 20.]

Distribution.—North-West India, Sikkim; West and South India, Ceylon, Assam, Burma, Tenasserim, extending on the east to China and Siam and southwards to Malacca, Java and the Philippines. (Bingham).

Food.—The spiny velvety black caterpillars of this butterfly are usually found feeding on the leaves of the climbing herb, *Aristolochia indica*, Linn. They probably feed on all species of *Aristolochia*. In October 1901 they were reported from Surat Farm as feeding on Kodu plants (*Lagenaria vulgaris*, Ser.). In July 1905 they were reported to be found on *Luffa ægyptiaca*, Mill. at Darbhanga. In the Insectary however they did feed on either of these plants. In the neighbourhood of Pusa they have never been found on any other food-plant except *Aristolochia indica*. The larvæ eat leaves and also green fruits if leaves run short.

Broods.—The butterfly hibernates in the pupal state. Frequently the hibernation is continuous with a further period of æstivation. In August and September 1906 large numbers of caterpillars and eggs were collected. They are found in numbers from June to September every year. Below is shown the behaviour of some of the pupæ which explains the hibernation and æstivation.

Larva pupated.	Butterfly emerged.	Duration of the pupal stage in days.
15th September 1906	30th March 1907	196
15th ,, ,,	15th July 1907	303
16th ,, ,,	29th September 1906	13

Larva pupated.	Butterfly emerged.	Duration of the pupal stage in days.
17th September 1906	29th September 1906	12
17th ,, ,,	30th ,, ,,	13
17th ,, ,,	3rd October ,,	16
17th ,, ,,	12th May 1907	237
18th ,, ,,	7th October 1906	19
18th ,, ,,	28th April 1907	222
19th ,, ,,	24th ,, ,,	217
19th ,, ,,	25th May ,,	248
10th August 1913	20th August 1913	10

Ordinarily the period of the life-cycle is about a month and a half. In the Insectary the latest butterfly before winter emerged on the 7th October and the first after winter on the 30th March. Thus it is evident that the insect may have only one generation or up to four or five generations at the most in the year, as sometimes breeding is continued far into the period of hibernation.

The egg. (Pl. V, figs. 1 & 2).—The egg is round and $1\frac{1}{2}$ mm. in diameter. Actually the egg-shell is smooth and like a thick dirty white membrane. But the appearance of the egg is red on account of the red contents and it is covered with a thick coating of a resinous substance. This coating is not smooth but is shallow at places, presenting broad and more or less regular furrows extending from a place at the top of the egg down the sides. The broad ridges are not uniform and continuous but consist of a number of yellow shining protuberant lumps of the same resinous substance. The egg is gummed on the surface of the leaf with this substance, a quantity of which is found collected under the egg so as to form a sort of a disc-shaped seat for it.

The eggs are deposited singly on the leaves, usually on their undersurfaces. In the Insectary no eggs were obtained from the butterflies. Eggs were collected from outside and from what has

been observed, the egg-stage seems to be about four or five days in ordinary temperature.

The larva.—The larva hatches from the egg by gnawing a hole in the shell and afterwards eats the empty shell. The young larva, a few hours after hatching, measures about 4 mm. long and about $\frac{3}{4}$ mm. in thickness and is cylindrical in shape. The head is black or very dark brown and shiny. The colour of the body is uniform yellowish-red. The prothorax has a dark brown shining transversely elongated shield situated in the middle of the pronotum. The larva is spiny possessing rows of fleshy spines of the same colour as the body along the sub-median regions and rudiments of other future spines so characteristic of the grown-up larva in the form of more or less distinct tubercles. These spines and tubercles are surmounted with long stiff brown hairs. The head and prothoracic shield too have similar hairs scattered on them. The five pairs of prolegs are equally developed and are of the same colour as the body. The legs are dark brown. The number of spines and tubercles on each side of the different segments are shown in the following table. As regards their position, those on either side of the median region on the back are called sub-median, those above and below the line of spiracles are called supra-spiracular and infra-spiracular respectively, those in a line with the spiracles spiracular, and those below the infra-spiracular, *i.e.*, at the base of the legs, are called sub-infra-spiracular.

——	Pro-thorax.	Meso-thorax.	Meta-thorax.	ABDOMINAL SEGMENTS.								ANAL SEG-MENTS.	
				1st	2nd	3rd	4th	5th	6th	7th	8th	1st	2nd
Sub-median spines		1	1	1	1	1	1	1	1	1	1	1	
Supra-spiracular spines.		1	1										
Spiracular spines	1												
Infra-spiracular tubercles ..		1	1	1	1	1	1	1	1	1	1		
Sub-infra-spiracular tubercles	1	1	1	1	1	1	1	1	1	1			

The sub-infra-spiracular tubercles are very small. On the second anal, *i.e.*, the last segment, there are two small tubercles in the sub-median position and similar tubercles on the ventral surface of the second abdominal segment just below the sub-infra-spiracular spines. Towards the end of the first stage and before the first moult, whitish spots appear round the prothoracic shield, *viz.*, a pair in front, a pair behind, and one beyond each extremity near the base of the spiracular spines; the sub-median spines and the tips of the infra-spiracular spines on the third abdominal segment become yellowish white.

After the first moult the resemblance with the grown-up larva becomes practically complete, except for the yellowish band which appears after the second moult and gradually becomes broader in successive stages. After the first moult the sub-median and infra-spiracular spines on the third abdominal segment are yellowish white, all the tubercles and spines lose the hairs, and all tubercles develop into short spines; the sub-median spines on prothorax and second anal segment found in the grown-up larva appear as small tubercles and gradually grow bigger.

Throughout the larval stage the caterpillar retains a general similarity of appearance. The colour changes from dark red to a velvety drab, *i.e.*, black with a reddish tinge. The full-grown larva (Pl. V, fig. 3) is about $2\frac{1}{2}$ inches long and about $\frac{1}{2}$ inch wide. It is cylindrical in shape and tapers slightly towards both ends. The head is dull black, the $\wedge$-shaped marking on it being red. The prothoracic shield is of the same colour as the head. The colour is uniform velvety drab, there being only a yellowish white band on the third abdominal segment extending to the infra-spiracular spine on each side. All the spines are beautifully red in colour except the four situated on this band which are of the same colour as the band. The yellowish white spots which appeared round the prothoracic shield in the first stage are red and appear like small tubercles, the pair behind the shield are big and may be considered

as spines. The spines on the grown-up larva on each side are as follows:—

	Pro-thorax.	Meso-thorax.	Meta-thorax.	Abdominal segments.								Anal segments.	
				1st	2nd	3rd	4th	5th	6th	7th	8th	1st	2nd
Sub-median	1	1	1	1	1	1	1	1	1	1	1	1	1
Supra-spiracular		1	1										
Spiracular	1												
Infra-spiracular..	..	1	1	1	1	1	1	1	1	1	1		
Sub-infra-spiracular.	1	1	1	1	1	1	1	1	1	1			
Ventral ..					1								

When the larva is disturbed or the wind blows against its body, it throws out from under the pair of red spots on the anterior part of the prothorax, a pair of very soft yellow processes like those of *Papilio pammon* and *P. demoleus*, but without the smell characteristic of them. In the case of *P. aristolochiæ* there is a faint smell like that of the fruits of its food-plant.

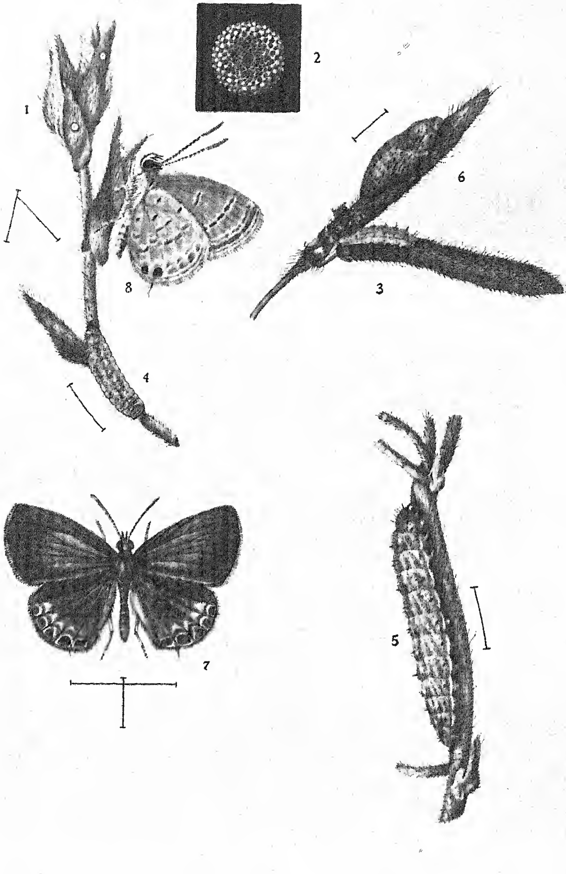
The caterpillar passes through five or six moults. In all the moults except the last at which pupation takes place, the moult of the head is cast separately. Before commencing the rest for moulting, the larva prepares a very thin silken padding on the surface of the leaf and entangles the hooks on the prolegs in its fibres. It walks a little forward when the skin is being slipped off posteriorly, rests a little and then turns round and eats the cast skin.

Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	6th moult.	Duration of larval stage in days.
21st Sep. 1906 ..	26th Sep.	30th Sep.	8th Oct.	18th Oct.	25th Oct.	9th Nov. pupated	49
12th June 1913 ..	15th June	18th June	20th June	23rd June	30th June, pupated	..	18

The larval stage of the first caterpillar is seen to last for forty-nine days. But it was noticed that some time before this larva hatched many had commenced hibernation in the pupal state. Hence its larval stage had to be passed in the hibernating period and was consequently prolonged.

The pupa (Pl. V, figs. 4 & 5).—When about to pupate the larva forms the usual silken padding. Pupation takes place on the food-plant or on the tree which forms the support of the food-plant, it being a climbing creeper. In the Insectary it took place on the wire-gauze of the cage. The hind or anal prolegs are entangled in the silken padding and a silken girdle across the metathoracic region holds the larva in position. Thus secured it rests before pupation with its head upwards. It voids a quantity of loose excreta before commencing the rest. After a rest of one to two days or more according to temperature, the larval skin is cast off and the pupa emerges. The pupa too is secured at the hind end and by the girdle. The pupa is brown and of a peculiar shape with flattened protuberances on head, thorax and abdominal segments, looking like a small conch-shell or a crumpled dry leaf. The pupal stage has been shown while discussing broods.

The imago.—The pupa develops a black tinge before the emergence of the imago. The butterfly comes out by bursting the suture between the head and prothorax of the pupa, the fissure extending along the antennæ up to about the end of the wing-case. At the same time there is another cleavage on the back running along the middle of prothorax and meso-thorax and then sideways to a certain extent. As the butterfly struggles out it voids a quantity of pink coloured liquid excreta in the pupa-case. After emergence it hangs on the deserted pupa-case until the wings develop and all the limbs harden. None of the butterflies bred in the Insectary lived for more than four days.



THE TUR HAIRSTREAK.

EXPLANATION OF PLATE VIII.

The Tur Hairstreak.

Catochrysops cnejus.

Fig. 1. Eggs laid on a shoot of *mung* (*Phaseolus radiatus*).

" 2. Egg magnified, X 50.

" 3. Larva boring into a *mung* pod.

" 4.} Larva.
5.}

" 6. Pupa on a *mung* pod, at the base of which is seen the hole bored by the larva with pellets of brown excreta sticking round it.

" 7.} The butterfly.
8.}

THE TUR HAIRSTREAK.

CATOCHRYSOPS CNEJUS, FABR.

THE TUR HAIRSTREAK.

(Pl. VIII).

[Bingham, Fauna of India, Butterflies, Vol. II, 1907, p. 415.]

Systematic position.—The butterfly, *C. cnejus*, belongs to the sub-family Lycæninæ of Family Lycænidæ.

Under this genus De Niceville lists nine species but he recognises only three and states the other six to be only the variable forms of these three species. (Butterflies, Vol. III, p. 176). Bingham agrees with him and adopts the same classification in the Fauna of India (Butterflies, Vol. II, pp. 415-416).

Distribution.—Throughout our limits except at very high elevations. Widely distributed in the Malayan sub-region; extending to Australia and the Southern Islands. (Bingham).

Occurrence.—At Pusa *Catochrysops cnejus* has been reared from egg, larva or pupa stage in February, April, May, June, July, September and October. It has been similarly reared by Mr. Ratiram Khamparia at Nagpur, Central Provinces, in May, November and December. It is thus found to be active throughout the year.

Food-plants and damage.—De Niceville bred the butterfly on *Phaseolus trilobus*, Linn. In Orissa it is reported to feed on *Dolichos catjang*, Roxb. At Pusa it has been reared on *arhar* (*Cajanus indicus*), *mung* (*Phaseolus radiatus*), *barbati* (*Dolichos catjang*), *barasim* (*Canavalia ensiformis*), *moth* (*Phaseolus acontifolius*).

At Nagpur it has been reared on *mung*, *arhar* and *barbati*. The larva feeds on flower buds or beans and will probably feed on any leguminous plant of a similar nature.

As regards the amount of actual damage, *C. cnejus* may very well be classed with the two known pests of the same family (Lycænidæ), *viz.*, *Virachola isocrates*, Fabr., known as the Anar caterpillar, which attacks pomegranate (Indian Museum Notes, Vol. I, p. 193, and Indian Insect Pests, p.179), and *Lampides elpis*, Godart, which attacks cardamom in Ceylon and Southern India (Indian Museum Notes, Vol. I, p. 11). In the case of *C. cnejus* the damage is not so apparent on account of the nature of the food-plant. The crops, which afford food to this insect, are usually cultivated on a very large scale and they usually put forth such a profusion of flowers and fruits that the damage caused by it, although it may be considerable, appears small and is not so much noticed. In one year in the spring as many as seven out of twenty flowers collected at random were found to be affected. Again a small plot of *mung* in the Insectary compound was so badly attacked in July that there could hardly be found a single pod unaffected.

Life-history.—The life-cycle of *C. cnejus* is shown in the table below. Its duration varies somewhat according to temperature :—

Egg laid.	Egg hatched.	Larva pupated	Butterfly emerged.	Duration in days.
	28th Feb.	18th March	29th March	18 + 11
		20th ,,	30th ,,	20 + 10
6th March	13th March	27th ,,	5th April	7 + 14 + 9 = 30
6th ,,	13th ,,	29th ,,	7th ,,	7 + 16 + 9 = 32
21st June	24th June	4th July	10th July	3 + 10 + 6 = 19

The Egg.—The egg is exactly round, flat and disc-shaped ; about ·6 mm. in diameter and about ·25 mm. thick ; white with a bluish tinge. On the upper surface of the egg there is a black or dark spot which is the centre of a slight depression or concavity in the middle. The surface is roughened with numerous regularly arranged raised points.

Eggs are usually laid singly on flowers, flower-buds and pods, sometimes on leaves and stems and rarely on other plants growing in the midst of and contiguous to the food-plant. One butterfly

while depositing eggs on *mung*, deposited one egg on the blade of a grass growing among the *mung* plants. The butterfly flits about the whole day, flying quickly here and there, sits for a moment on a plant, bends the abdomen, touches the surface with the tip of its abdomen, deposits the egg and soon flies away again. Before hatching the colour of the egg turns a little dark in the middle of the disc. The larva hatches by gnawing the middle portion of the upper surface of the shell but does not eat the egg-shell after emergence. The empty egg-shells are white and stick to the plant with a gaping hole at the top.

The larva.—The young larva is about $1\frac{1}{4}$ mm. long, flattened, the margins of the body being practically parallel. In shape it resembles the grown larva, only the head is comparatively large, being about equal in breadth to the body. The head is black and shiny. The prothorax bears a black shield which looks like a big black spot at the middle of the pronotum. The colour is slightly greenish and greyish pale yellow, with a faint yellowish-brown stripe along each sub-median region on the back. The thoracic and the first six abdominal segments are distinguishable as in the adult larva. The seventh, eighth and ninth abdominal segments merge into each other and are not distinguishable unless looked at from the ventral side. The thoracic legs and five pairs of prolegs are quite clearly seen. The whole body is covered with somewhat longish hairs. The larvæ grow without any remarkable change in shape but show a variation in colour. From the beginning some are green while others are reddish brick colour. The green larvæ hardly undergo any change in colour. The ventral surface of the reddish larvæ is green and they may retain the reddish colour of the back till some time before pupation or may gradually become green by about the middle of the larval life retaining only a brownish mid-dorsal stripe and a very few faint oblique markings of the same colour on each side of the back.

A full-grown green larva measures about 16 mm. long by about 4·5 mm. across the body, is flattened, the margins of the

body being almost parallel, only the thoracic region tapering anteriorly. The back is convex and the ventral surface is flat. The margin of the hind end is rounded and so is that of the prothorax. The head is black, shiny and small and usually remains hidden under the prothorax. All the segments of the body up to the sixth abdominal are more or less distinct. Then the remaining segments merge into each other. The colour is uniform green, the dorsal vessel showing as a darker mid-dorsal stripe; and in addition there are, on each side of back, very faint oblique whitish markings. The legs and prolegs are also green. A full-grown reddish brown larva measures about the same. Its pronotum is entirely reddish-brown. Meso-thorax and meta-thorax are almost similarly coloured but the sub-median regions of these segments are paler. The mid-dorsal region of the remainder of the body is reddish-brown and also the margins. There are oblique greyish markings on the sides. On account of the reddish-brown colouring the larva looks different from an ordinary green one. Before pupation the colour changes to that of the green larva, the brown portions becoming faint. The spiracles appear as small round brown spots; the prothoracic and the first six abdominal pairs are situated laterally near the margins of the body; but the seventh abdominal pair (fig. 1) is situated on the dorsal surface, one on each side of the secreting gland; the eighth abdominal pair is also situated on the back and near the mid-dorsal region.

The larvæ secrete silk throughout the larval stage, and if they are disturbed much and have to let go their hold on the plant, they hang down by means of this silk. Not infrequently a larva may be found hanging in the air and sometimes with an ant on its back.

As has been said above, the eggs are laid on very tender flower buds generally when the corolla is yet enclosed within the calyx. The bud grows by the time the eggs hatch and the young larva bores a hole in the corolla, enters the interior of the flower and eats the stamens and the pistil. The flower generally shows no external signs of injury, the hole made in the corolla being very small. The larva has grown considerably by the time the stamens and the

pistil are consumed. It comes out by eating a portion of the corolla, continues destroying the flowers for some time and then attacks the pods. A hole is made in the pod, the body is thrust half-way in and the seed opposite to the hole is eaten. Separate holes are usually made by a grown-up larva to get at the seeds. The younger larva enters the pod bodily and eats one seed after another. The larval moults are shown below :—

Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.
24th June 13th March	27th June 17th March	29th June 21st March	1st July 25th March	4th July (pupated) 29th March (pupated)

Ants and the larva.—The larvæ are attended by two kinds of ants; one is the big black one (*Camponotus compressus*, Fabr.) which has been found to follow them both at Pusa and at Calcutta, and the other is a small brown one (*Tapinoma melanocephalum*). They are attended by either of the two kinds but never by both at the same time. There may be three or four or more ants attending one larva. The actions of the big black ants (*Camponotus compressus*) are more easily observable. The ants gently stroke the back of the larva with their antennæ and sometimes continue to do so while sitting on the back of the larva while it moves along. The ants are very quick in movement and continue to run hither and thither, seldom going far away from the larva, although

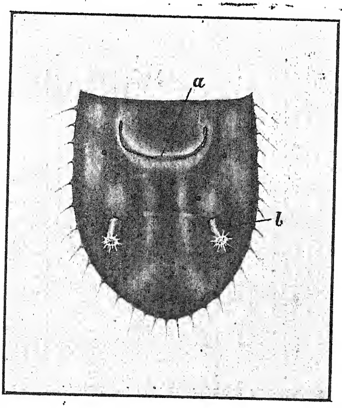


Fig. 1. Hind part of the larva of *C. cnejus* showing *a*, aperture of secreting gland, and *b*, the eversible process.

the larva may be moving about and always returning to it and stroking it with their antennæ. The ants are attracted by a white, almost tasteless and very slightly viscous liquid exuded from an aperture on the back of the seventh abdominal segment (Fig. 1, a). The ants come and lick it up. If it is not removed for some time, the liquid collects as a clear drop of watery looking fluid. The aperture is crescent-shaped, the projections or arms of the crescent being turned anteriorly. The liquid is exuded from the middle of the crescent and the ants also come and feel this part with their mouth-parts to see whether any liquid has collected. The aperture is capable of being opened and closed at the will of the larva. At times, usually when an ant is licking the middle of the crescent, a small yellow process is protruded from each arm of the crescent, the head of the process bearing a number of small radially arranged hair-like projections. These processes are thrown out only occasionally and are soon retracted. Their function does not seem to be at all clear.

From a place almost exactly on the junction of the eighth and ninth abdominal segments and much towards the margin on each side of the body is a process (Fig. 1, b) capable of being protruded and retracted. It is about $\frac{1}{2}$ mm. in length, cylindrical rod-shaped with a rounded head which bears a number of hair-like projections arranged radially. In colour it is more or less transparent dirty white and so also are the hair-like projections. These two processes are thrust out frequently, especially when the ants move away from the larva. From a distance each looks like a drop of water standing out in relief. Either both or one may be protruded at the same time. Sometimes they are retracted and thrown out so quickly that a rapid flickering effect is produced or at times may be only about half everted. They are in small cavities and when completely retracted a round spot is noticeable in their place paler than the surrounding regions. These two processes seem to serve as a means for attracting the ants from a distance. The larva does not seem to be very much affected by the overtures of the ants; it feeds or walks about almost indifferently although the ant may

be sitting on its back, or stroking it with its antennæ or licking the aperture of the secreting gland.

Pupa.—The larva before pupating applies some silk in the form of a thin layer on to the pod or on to the stem and sits with its feet entangled in the fibres. A girdle of silk is also passed round the body at about the first abdominal segment and the ends of the girdle are fixed to the surface of the pod or stem on each side. The skin is then cast off and the larva pupates.

The pupa is about 10 mm. long and measures about $3\frac{1}{2}$ mm. across the abdomen and about $2\frac{1}{2}$ mm. across the thorax. The region between the thorax and abdomen is somewhat constricted. The colour is green at first but changes to a dirty brown with black speckles. The pupa lies on its ventral surface and is held in position by the girdle. It is also held at the hind end by means of a number of short curved-tipped hairs which are entangled in the fibres of the silken pad. The attendant ants, which were confined with the larva, were found clustered round the newly-formed pupa; but the pupa was not observed to secrete anything and was eventually deserted. The pupal stages are shown in the statement of life-cycle; others are :—

Pupated.	Butterfly emerged.	Duration in days.
24th March	2nd April	9
14th April	21st ,,	7
29th June	4th July	6
4th July	10th ,,	6
28th November	15th December	17

The butterflies.—The butterflies are quick-flying, restless creatures and rarely rest anywhere for any length of time. They may rest for a few seconds and then fly away, fluttering about and may traverse several yards before settling again. When they sit the wings are usually held folded up above the back; but they are sometimes in the habit of alternately opening and closing the wings, at the same time turning either to the right or to the left. Their flight also is a sort of fluttering, quick alternate opening and closing

of the wings, and the path they describe is neither level nor straight but is an undulating curve or zig-zag. At times two butterflies, probably the male and female together fly in such a way that it is not easy to distinguish whether one or two are in flight. Then one, probably the female, settles while the other, probably the male, still flutters about; the female at this time may unfold the wings and bring them down flat on each side and raise the abdomen. Then suddenly she takes to flight and both go away sportively as before. This probably is their courtship. At times however the male flits away and does not return.

Enemy.—One species of the Ichneumon has been found to be parasitic on the larvæ of these butterflies. The larva pupates with the Hymenopterous grub in its body. After some days the Ichneumon fly emerges by making a hole in the pupa-case.

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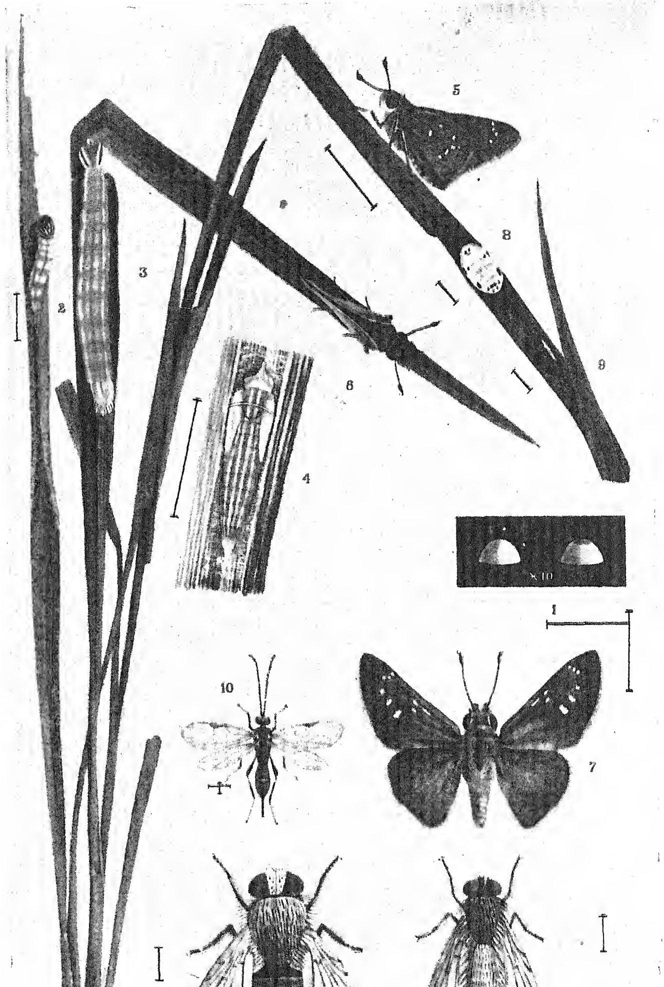


RICE SKIPPER.

EXPLANATION OF PLATE IX.

Parnara (Chapra) mathias.

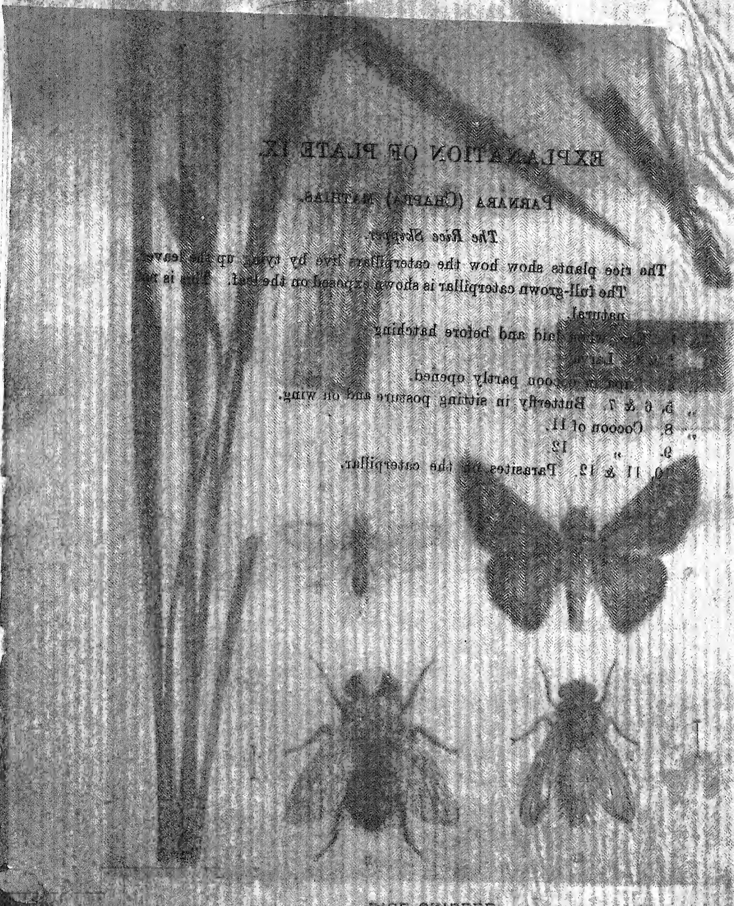
The Rice Skipper.

The rice plants show how the caterpillars live by tying up the leaves. The full-grown caterpillar is shown exposed on the leaf. This is not natural.

Fig. 1. Egg, when laid and before hatching.
,, 2 & 3. Larva.
,, 4. Pupa in cocoon partly opened.
,, 5, 6 & 7. Butterfly in sitting posture and on wing.
,, 8. Cocoon of 11.
,, 9. ,, 12.
,, 10, 11 & 12. Parasites on the caterpillar.

rice leaves. The butterfly is figured in Indian Museum Notes, Vol. V, Plate IX, figure 6. He states that the larva eats other grasses also.

The student of Indian insects may be cautioned against confusing this insect with the similar form, *Suastus gremius*, Fabr., also described by de Niceville as a pest of rice from Balasore (Ind. Mus. Notes, I, p. 9). The butterflies are superficially similar, and the life-history practically the same. The most ready means of distinction lies in the markings, *Chapra mathias* having white spots on the lower surface of the hind wing, *Suastus gremius* having black ones. This is of course purely superficial, the two genera being distinct in morphological characters. The larvæ of both were reared by Davidson and Aitken in Kanara, the latter from cocoanut



RICE SKIPPER.

PARNARA (CHAPRA) MATHIAS, FABR.

THE RICE SKIPPER.

PLATE IX.

Swinhoe—Lep. Ind. Vol. X, 1913, p. 320.

Distribution.—This seems to be about the most widely distributed and generally common species in Asia, extending from Syria to the Linkin Islands and Sambawa. It occurs all over India from Kashmir to Malabar, and from Bombay to Pegu and the Malay Peninsula. In addition to the above named localities, I have it from Borneo, Bali, Japan and China; and Semper states that it is generally distributed in the Philippines. Holland also records it as *Baoris chaya* from Hainan. (Edwards).

Occurrence and food-plants.—*Chapra mathias*, Fabr., is referred to by de Niceville in Indian Museum Notes, Vol. V, p. 137, as having been found as a larva in October in Calcutta, feeding on rice leaves. The butterfly is figured in Indian Museum Notes, Vol. V, Plate IX, figure 6. He states that the larva eats other grasses also.

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palm; the larva of former is described as having a red, the latter a brown line on the head. (Journ., Bombay Nat. Hist. Soc., Vol. V, p. 371).

Parnara colaca, Mo., is stated to have fed on paddy in Saran. (Ind. Mus. Notes, Vol. III, p. 113). At Pusa this as well as *Taractrocera sagara* are found commonly with *Chapra mathias* larvæ. This last has been recently reported feeding on rice from Kidderpur, Kanara and Thana, Bombay. It was found in a caterpillar swarm at Daltonganj in Bihar along with *Spodoptera mauritia*, *Lucania* spp. and others. It occurs throughout India.

These caterpillars as well as the larvæ of *Taractrocera sagara* have fed indiscriminately on leaves of rice, maize, *juar* (*Andropogon sorghum*), *kodo* (*Paspalum scrobiculatum*), *marua* (*Eleusine coracana*) and *dub* grass (*Cynodon dactylon*). In September and October the butterflies freely laid eggs on *kodo* growing in the Insectary compound. It would appear that they have a wide range of food-plants under the natural order Graminæ. The caterpillars are in the habit of hiding themselves by folding over a leaf or bringing two or more leaves together and fastening them by means of a white silk exuded from the mouth. This is very clearly seen in the plate. They thrust the head out from this hiding-place and eat the leaves from edge inwards. It is a minor pest of rice.

Life-history.—Below are shown the periods of the life-cycle observed in the Insectary in summer and winter temperatures :—

——	Egg hatched.	Larva pupated.	Butterfly emerged.
(1) Egg laid, 18th September ..	21st Sept.	11th October	20th October.
(2) Egg collected, 25th September ..	28th ,,	18th ,,	27th ,,
(3) ,, ,, 10th November ..	13th Nov.	22nd January	21st February.

The period of the life-cycle occupies a little over a month in ordinary summer temperature. But it extends over $3\frac{1}{2}$ months in winter. When the third larva pupated in January, the weather

began to get distinctly warmer. Normally the winter seems to be passed in hibernation in the larval stage. (This has also been found to be the case with *Taractrocera sagara* a larva of which hibernated from 11th October to 2nd April).

The egg.—The egg is hemispherical in shape with a perfectly flat base. The diameter at the base is about 1 mm. and the height vertically from the base to the top is about $\frac{1}{2}$ mm. The surface is smooth and the colour creamy white. Before hatching a big black spot appears at the top. This is the head of the embryo showing through the shell. Under a lens the jaws also of the embryo are visible biting at the shell. The eggs are laid singly on the upper surfaces of leaves of the food-plants.

The larva.—The newly-hatched caterpillar is about $2\frac{1}{2}$ mm. long, semi-cylindrical with a convex back and flat ventral surface. The head is much bigger in diameter than the body, being about $\frac{2}{3}$ mm. across while the body is about $\frac{1}{3}$ mm. in breadth. It is flat in front and rather triangular in shape. The colour is black shiny. Its long axis is more or less at right angles to the long axis of the body. The prothorax has a narrow black plate like a half collar on the dorsal surface. The segments of the whole body, twelve in number excluding the head, are indistinct. There are five pairs of prolegs, but the legs and prolegs are short, so that when the larva rests or walks, its ventral surface seems to touch the surface. While the larva walks it is in the habit of swaying the head from side to side. The hind segment is flattened and rounded at the posterior margin. The colour is uniform pale yellow but it soon changes and becomes green when green food is taken. The young larva hatches by gnawing a hole in the shell and then eats the deserted shell either wholly or partly.

The following is the record of the growth of a larva which hatched on the 28th September:—

1st October.—Moulted (first time). The larva is about $3\frac{1}{2}$ mm. long. The collar on prothorax is not black now but light brown. There is hardly any more change. The head is not as shiny as before

5th October.—Moulted (second time). The larva is about 6 mm. long. The appearance is about the same. A thin white stripe is perceptible on each side of the median region and one more on each side of body; besides, a thin white line along the spiracles.

7th October.—Moulted (third time). Length about 10 mm. Appearance the same as in previous instar.

11th October.—Moulted (fourth time). The larva is about 17 mm. long, $2\frac{1}{2}$ mm. across head and $2\frac{1}{4}$ mm. across body. The head is not entirely black now; a white spot has appeared above the clypeus; two white broad longitudinal stripes have appeared, one on each side, and the posterior part has become dirty green. The colour of body is slightly yellowish-green; the four white narrow stripes on the back are distinct, the spiracular one is not so distinct. As from the beginning the segments are not distinct. At each successive moult the anal segment becomes flatter, its posterior margin being completely rounded.

12th October.—Measures 23 mm. in length, growing very quickly, has grown 6 mm. in 24 hours.

14th October.—30 mm. by $3\frac{1}{2}$ mm. across middle of body; tapers slightly to hind end but more prominently to the thoracic region, the prothorax being less than 2 mm. in thickness. Colour green including that of legs and prolegs; the back looks greenish white as if covered with a white powder.

18th October.—Pupated.

25th October.—Eyes of pupa become brown.

26th October.—Colour of pupa become dark.

27th October.—Butterfly emerged.

Moults.—The larva passes through four larval moults and pupates at the fifth. The following table shows the periods of the different instars.

Larva hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult, pupated.
21st Sept. 28th ,,	24th Sept. 1st Oct.	27th Sept. 5th Oct.	30th Sept. 7th Oct.	3rd Oct. 11th ,,	11th Oct. 18th ,,

In all the larval moults except the last at which the larva turns into the pupa, the head moult is cast separately and entire. The skin is not slipped off posteriorly; on the other hand, the larva walks out of it and it remains sticking to the place. After some

time the larva turns round and eats it. In the last moult, the head moult sticks to the skin, the fissure liberating the pupa extends over the vertex of the head and down each side of clypeus to near the mouthparts. The skin is slipped off posteriorly and it collects as a crumpled mass at the end of the pupa.

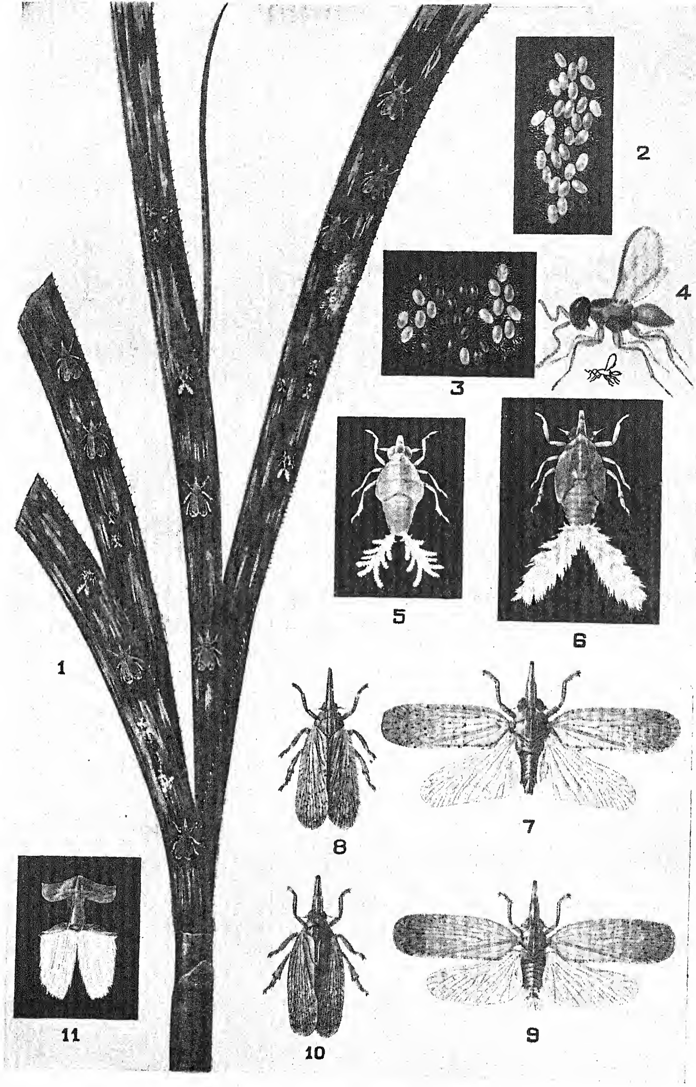
Pupa and pupation.—The caterpillar pupates on the plant. The leafy house or case which forms the hiding-place of the larva is lined with silk thus being converted into a cocoon. Pupation takes place in this cocoon. The pupa is about 23 mm. long from end to end and measures about $4\frac{1}{2}$ mm. across the thorax. It is cylindrical in shape, tapering gradually towards hind end. The head is protruded into a tapering narrow snout about 2 mm. in length. The cremaster is a transversely flattened projection bearing a number of small circinate stiff hairs on the posterior margin. These circinate hairs remain entangled in the silken fibres of the cocoon. The colour is green ; the same stripes are perceptible on the back of the pupa as are seen on the back of the larva. As the pupa advances in age the wings which are folded on the ventral surface turn paler in colour. Before the emergence of the butterfly the colour becomes dark or almost black. The pupa-case is thin, white and almost transparent. The parts of the butterfly are therefore almost clearly visible.

The butterfly emerges by bursting the pupa-case along the mid-dorsal thoracic region, the fissure extending to the base of the snout and then going sideways near or over the eyes and along the regions of the antennæ. The empty pupa-case is left inside the cocoon.

The imago.—The butterflies are in the habit of sitting with their wings folded up over the back as shown in the figures 5 & 6. The wings are sometimes held a little apart from one another. The butterfly looks like a crumpled dry leaf in this posture. It rests in this position for long periods at a time. It is a quick flier but does not remain on the wing long like other butterflies. It flies with darting movements and comes to rest on bush, tree or ground and after varying periods of rest takes to wing again.

Enemies.—The caterpillars are parasitised by several parasites, both Dipterous and Hymenopterous and are preyed upon by the Pentatomid bug, *Andrallus spinidens* which sucks the body fluid and kills the victim. Three of the parasites are shown in figures 10, 11 and 12, Pl. IX. The seed-like bodies on the leaf are the pupæ of the flies, figs. 11 and 12, Pl. IX.

The maggots come out of the body of the dead caterpillar and pupate on the leaf in this fashion. These enemies keep down the number of the caterpillars so that they can hardly increase to the extent of proving a serious pest.



PYRILLA ABERRANS.

THE INDIAN SUGARCANE LEAF-HOPPER *PYRILLA ABERRANS*, KIRBY.

BY

C. S. MISRA, B.A.,

First Assistant to the Imperial Entomologist.

[Received for publication on 22nd June, 1915.]

INTRODUCTORY.

It was early in the year 1905 that the appearance of leaf-hoppers in large numbers in the experimental series of canes at Pusa first drew attention to this insect. From that time the presence of the hoppers has been carefully watched, as it was then thought that in future years it might become a pest and seriously damage the varieties of canes that were grown experimentally at Pusa. These expectations were soon fulfilled, as in the following year the hopper overran the varieties of canes by the beginning of [illegible] and was at its worst during September to November. During this period it was in such development that it was impossible to save the crop from being seriously damaged. It was at this time that the study of the pest was commenced to find out the vulnerable points in its life-history and the measures which would check it efficiently in the following years.

A study of the pest during the past nine years has revealed the fact that it is only in occasional years that it is bad. From 1906-1914 the hopper has only been noticed to be bad in 1906, 1907, 1910, and 1914. During the other years it was present but in such numbers as not seriously to injure the crop. The reason for this unequal distribution seems to be the presence of parasites as well as the prevalence of the climatic conditions. If a cold weather is followed by extreme heat during April, May, and June and if thereafter the rains are copious, the hopper is checked from developing and overrunning the cane crop during the following months of the year. Besides this, continuous observations in the fields have demonstrated the particular fondness of the hopper for the broad-leaved varieties of sugarcane. If, however, the area under thin-leaved varieties of cane is larger than that of the thick-leaved varieties, there is only a restricted development of the hopper. It is for this

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A study of the pest during the past nine years has revealed the fact that it is only in occasional years that it is bad. From 1906-1914 the hopper has only been noticed to be bad in 1906, 1907, 1910, and 1914. During the other years it was present but in such numbers as not seriously to injure the crop. The reason for this unequal distribution seems to be the presence of parasites as well as the prevalence of the climatic conditions. If a cold weather is followed by extreme heat during April, May, and June and if thereafter the rains are copious, the hopper is checked from developing and overrunning the cane crop during the following months of the year. Besides this, continuous observations in the fields have demonstrated the particular fondness of the hopper for the broad-leaved varieties of sugarcane. If, however, the area under thin-leaved varieties of cane is larger than that of the thick-leaved varieties, there is only a restricted development of the hopper. It is for this

reason that complaints about the presence of the hopper have now begun to be received from localities in which broad-leaved varieties have been planted on a fairly large scale. Mr. J. McGlashan, of the Central Provinces and Berar Sugar Syndicate Co., Ltd., Talodi-Balapur, District Chanda, C. P., in his letter dated the 1st October, 1914, said that a brown insect was present in quantity on the sugarcane on his farm.

It is only recently that the Manager of the Kasandra Irrigation and Agricultural Works, Kasandra, District Ahmedabad, wrote that the hopper was bad in his plantation and the affected cane leaves received from him for examination were full of the nymphs and the adults of the hopper. Thus, with the attention that is at present being given to the extension and improvement of sugarcane cultivation in India, it would be advisable not to lose sight of the presence of such pests as might affect the crop and limit its extension. The fact why more reports are not received regarding the damage done to sugarcane by the pest in the ryots' fields in India generally is due to the fact that the damage brought about by it is imperceptible in the beginning. It is in the later stages that the damage becomes known and is then ascribed to the paucity of rain or the prevalence of adverse climatic conditions. But if continuous observations are made in the field it will be known that it is the hopper which, by draining away the sap that would have gone to the strengthening of the plants, weakens them at a critical stage of their growth. When once so set back the crop takes time to regain its vigour and, being lowered in vitality, falls an easy prey to other pests both insect and fungoidal. These conclusions are the result of continuous observation of the cane crops through the past nine years at Pusa, as well as at other places during my tours. During 1908, when I was at Nagpur and had an occasion of examining the Kachhi's plots at Lendhra near Nagpur, I was struck with the number of the hoppers on the leaves and the consequent poor condition of the crop, but on asking the proprietors of the fields, who were themselves very good cultivators, I was surprised to hear that the poorness of the crop was ascribed to the prevalence of hot winds at the time of the growth of the plants. A similar experience was met with at Cawnpore during 1908 and at Baroda during 1912. In short, it is because the pest is so insidious in its attack in the beginning that it does not receive the recognition which is its due.

Historical.

The leaf-hopper was for the first time reported as a pest to sugarcane from the North Arcot District in South India in 1900 and the Agricultural Officer, in forwarding specimens for identification, wrote : " These insects

are seen to perch on the underside of the cane leaf avoiding sun and on shaded leaves. They are good springers. The bug is soft-bodied and is very easily killed by slight handling. These are known to the ryots only since ten years. The cane crop when infested gets stunted and damaged. These appear when cane is six to nine months old."

It was subsequently observed on sugarcane (*Indian Museum Notes*, Vol. V, No. 2, p. 43) by the late Mr. Lionel De Nicéville at the Cawnpore Experimental Farm in 1901 and the observations then recorded by him hold good at the present time also. The life-history of the pest was not then studied in detail and the hopper was identified as *Dictyophara pallida*, Don., which it does not resemble either in shape, colour, or habits.

The leaf-hopper has been hitherto known as *Dictyophara pallida*, Don., and was first identified and figured as such in *Indian Museum Notes* (Vol. V, No. 2, p. 43, 1900). Mr. W. L. Distant recorded *D. pallida* as damaging sugarcane in the *Fauna of British India, Rhynchota*, Vol. III, p. 244, and reproduced the description of the Agricultural Officer, North Arcot District, given above. Thus there was some confusion in the identity of the species of the leaf-hopper infesting the sugarcane in India and it is strange that the figure in *Indian Museum Notes* (Vol. V, No. 2, Plate V, fig. 1) did not bring out the identity of the pest earlier. The drawing is fairly accurate and gives a good idea of the species infesting the sugarcane excepting that five longitudinal carinations on the mesonotum are shown instead of three as is really the case. Except for this defect the specimen figured there corresponds fairly accurately with *Pyrilla perpusilla*, Walk. It was in the year 1907 that the late Mr. G. W. Kirkaldy drew attention to the real identity of the pest (*Annales de la Société Entomologique de Belgique*, Tome LI, 1907, pp. 123-124) and said that the Sugarcane Leaf-hopper, hitherto known as *Dictyophara pallida*, Don., was no other than *Pyrilla aberrans*, W. F. Kirby. The generic determination was subsequently accepted by Mr. W. L. Distant and he further pointed out (*Annales de la Société Entomologique de Belgique*, Tome LI, 1907, p. 220) that the species was not *Pyrilla aberrans*, Kirby, but *Pyrilla perpusilla*, Walk. He says: "If the figure in the *Indian Museum Notes* given as *Dictyophara pallida*, which I did not quote, is to be ascribed to *Pyrilla* then despite the five carinations to the mesonotum it is *P. perpusilla*, Walk., and not *P. aberrans* as so confidently stated by Kirkaldy. That confusion does exist in India regarding the *D. pallida*, Don., despite the accurate determination of Atkinson, is, I am aware, the case. I have received a series of specimens from Mr. Lefroy collected in the Plains of India where it is destructive to sugarcane and these represent the *P. lycoides*, Walk."

That there was confusion was no doubt the case. *Dictyophara pallida*, Don., hitherto known as the Sugarcane-fly, does not occur on sugarcane at all; at least during the past ten years I have never come across a single specimen of *D. pallida*, Don., on sugarcane in any part of India. *Dictyophara sauropsis*, Walk., a species closely resembling *D. pallida*, is found on *Tamarix gallica*, Linn., and on grasses at Pusa and occasionally comes to light, especially in the beginning of the rains. *D. pallida* differs markedly from *Pyrilla aberrans* in the shape and colour of the tegmina as well as the porrect head with its cephalic process. Its habits are quite different from those of *Pyrilla aberrans* which is gregarious and appears in swarms on cereals and especially on sugarcane. The figure of *D. pallida*, as shown on Plate V, *Indian Museum Notes*, Vol. V, No. 2, shows five longitudinal carinations on the mesonotum dorsally instead of three as actually present in a specimen which I have had before me from the original Atkinson collection from Raniganj, Bengal, and which was kindly lent by Mr. F. H. Gravely of the Indian Museum, Calcutta. The tegmina and legs of this specimen are damaged; hence it has not been possible for me to compare it with the figure given in the *Indian Museum Notes*.

Species affecting the Sugarcane in India.

When the study of the pest began early in 1906, it was thought that only one species, *Pyrilla aberrans*, Kirby (*Dictyophara pallida*, Don., as it was thought then), was concerned with the damage to sugarcane. Further on, as the studies advanced, it was found that instead of one, two species were mixed up in the swarm which did considerable damage to the experimental sugarcane plots at Pusa in 1907. The observations regarding the habits of the leaf-hopper were continued in the field from 1906-1914, when early in 1914 a series of specimens were sent to Mr. Distant for specific determination and he returned them saying that they were of three species:

Pyrilla aberrans, Kirby; *Pyrilla perpusilla*, Walk.;
and *Pyrilla pusana*, Dist.

The last, he said, was new to Science and was described by him in the *Annals and Magazine of Natural History*, Vol. XIV, No. 82, page 326, as follows:—

"Family Fulgoridæ.
Sub-family Lophopinæ.
Pyrilla pusana, n.sp. (Distant).

"Body and legs shining brownish ochraceous; pronotum and mesonotum usually more or less darker in hue, sometimes concolorous, sometimes dark

castaneous; tegmina dark shining ochraceous, the apical area moderately infuscate with many black spots. Some minute dark spots varying in number on anterior disk; wings very pale infuscate.

Allied to *Pyrilla lycoides*, Walk., but differing by the less robust cephalic process.

Length excluding tegmina, 7-8 mm.
Expansion tegmina, 20-21 mm.
Hab. Pusa, Bihar."

The first two, *P. aberrans* and *P. perpusilla*, were described in the *Fauna of British India*, Vol. III, pp. 326-327, under the names *Zamila aberrans*, Kirby, and *Z. perpusilla*, Walk. But for the sake of differentiating the species I append on page 78 a table of characteristic differences.

Pyrilla aberrans, Kirby. *Zamila aberrans*, Kirby. Fauna India, *Rhynchota* III, 326-327.	*Pyrilla perpusilla*, Walk. *Zamila perpusilla*, Walk. Fauna India, *Rhynchota* III, 327.	*Pyrilla pusana*, Dist. A. M. N. H., Vol. XIV, No. 82, Oct. 1914, page 326.
BODY AND LEGS. Ochraceous. Lateral areas and under-surface of cephalic process much paler.	BODY AND LEGS. Ochraceous, paler beneath than above.	BODY AND LEGS. Shining, brownish ochraceous.
TEGMINA. Very pale tawny yellow, opaque, apical area speckled with minute fuscous spots and with two short transverse fuscous lines near apical margin.	TEGMINA. Yellowish white, semi-opaque, the apical area and outer claval margin speckled with minute black spots.	TEGMINA. Dark shining ochraceous, the apical area moderately infuscate with many black spots, some minute dark spots varying in number on anterior disk.
WINGS. Greyish, slightly suffused with very pale fuliginous.	WINGS. Pale Hyaline.	WINGS. Very pale infuscate.
MESONOTUM. Disk between the carinæ brown.	......	PRONOTUM AND MESONOTUM. Usually more or less darker in hue, sometimes concolorous, sometimes castaneous.
CEPHALIC PROCESS. Above the medial transverse ridge with the central longitudinal carination very distant.	CEPHALIC PROCESS. The dorsal ridge to cephalic process is much less prominent in front of the central transverse ridge than behind it.	
Length (excluding tegmina)—7-5 mm.	Length (excluding tegmina)—9 mm.	Length (excluding tegmina)—7-8 mm.
Expansion of tegmina—16 mm.	Expansion of tegmina—18 mm.	Expansion of tegmina—20-21 mm.

In the North-West of India, including the North-West Frontier Province and the Punjab, *Pyrilla aberrans* is widely distributed; though with wider collection it is possible that the other species may also be found to exist in large numbers in some special tracts of these Provinces. In the United Provinces, especially at Cawnpore, *Pyrilla aberrans* is more widely distributed than the other two species. In the Bombay Presidency, both the species, *Pyrilla perpusilla* and *P. aberrans*, are fairly commonly distributed. An examination of specimens received in the middle of December 1914 from the Manager, The Kasandra Irrigation and Agricultural Works, Kasandra, Ahmedabad, showed that *Pyrilla perpusilla* preponderated over *P. aberrans*. That the damage brought about by the two species is the same is also corroborated by the observations of the Manager who while sending the specimens wrote :—

"Under separate cover we are also sending you in a tin box some insects. They are of two varieties. One are small and whitish and others are big winged. These adhere to leaves and they draw out all the sweetness out of the leaves. On the leaves they adhere, small wet spots of sugar are very distinctly marked."

In the Madras Presidency, so far as can be made out from specimens in the Pusa collection, as well as those received from the Indian Museum for examination through the courtesy of Mr. F. H. Gravely, *Pyrilla perpusilla* occurs exclusively. These latter specimens formed part of the original collection which was forwarded by the Agricultural Officer of the North Arcot District in 1900 to the Indian Museum and which were described and figured as *Dictyophara pallida* (*Indian Museum Notes*, Vol. V, No. 2, p. 43, 1900, Plate V, figs. 1-6). That *P. perpusilla* is the species found infesting sugarcane in South India is also borne out by a note on the species in Mr. Bainbrigge Fletcher's book on "Some South Indian Insects," pp. 493-494. Nothing definite is known about the distribution of the species in Bengal and Assam. Only recently Mr. Bainbrigge Fletcher, the Imperial Entomologist, whilst touring in Burma, collected a specimen on sugarcane at Pyinmana and this was closely allied to *Pyrilla lycoides*. The specimen has been sent to Mr. Distant for verification. In the Central Provinces *Pyrilla aberrans* and *P. pusana* are both met with, but possibly the latter preponderates over the former. This was especially the case on the Home Farm of the Central Provinces and Berar Sugarcane-growing Syndicate, Talodi-Balapur, District Chanda. A count made on the Farm during July 1914 showed that fully 73 per cent of the adult hoppers then present on the leaves were *P. pusana*. This fact was further brought out by taking the percentage of specimens sent later on by Mr. McGlashan, Manager of the Syndicate, to Pusa for identification. In Bihar, and especially in Tirhut and in close proximity to Pusa, all

the three species, *Pyrilla perpusilla*, *P. aberrans*, and *P. pusana*, occur in some abundance, and the distribution of the species throughout the year, as observed in the experimental plots in the past, is remarkable. In some years in the beginning of the season, especially from March to the beginning of May, *P. perpusilla* was more common. This was then followed by *P. aberrans*, and in some years the two were present in nearly equal proportions on the plants from March to June. Later on, from July to September, *P. aberrans* was to be found in large numbers with a fair sprinkling of *P. perpusilla* and *P. pusana*. By the end of the season, October to November, *P. pusana* was to be found in large numbers. During 1906 *P. aberrans* increased in such large numbers that it overran the whole crop and did much damage to the broad-leaved varieties of canes. The eggs were laid so profusely that a Pipal tree (*Ficus religiosa*) adjoining the sugarcane plantation was covered with eggmasses to a height of thirty feet from the ground. The tree became so prominent that it looked as if it were white-washed (Plate XI, fig. 1). The bamboo clumps, which were close by the sugar-cane fields, were full of egg-clusters and in some cases they had become white with the cretaceous white masses on them. Even the clods in the fields, as well as the brickbats below neighbouring trees, were thickly covered with eggs. The year 1906 was the worst and it then brought out the fact that the leaf-hopper, which had hitherto remained as an unimportant pest, was not to be lost sight of in the economy of successful sugarcane cultivation in the North of Bihar, and especially so in certain years when the climatic conditions were favourable to the rapid development of the pest (Plate XI, fig. 2). The notes herein contained refer mostly to *P. aberrans* which has been under observation during the past nine years and the life-history of which has been studied in detail. The habits and life-histories of the other three species do not differ much from one another and for purposes of economic work they may be dealt with together.

Vernacular Names of *Pyrilla* sp.:

Central Provinces : Khairi, Machhi, Dans, Machhad.
Madras : Cheeda purugu (North Arcot, *Faun. Ind.*, Vol. III, p. 244).
Thathu poochi (Coimbatore, *Faun. Ind.*, Vol. III, p. 244).
Thaloocu poochi (*Ind. Mus. Notes*, Vol. V, p. 43).

Nature of Injury to the Plants.

Dr. Sharp has very truly said : " There is probably no order of insects that is so directly concerned with the welfare of the human race as the Hemiptera; indeed, if anything were to exterminate the enemies of Hemiptera, we ourselves should probably be starved in the course of a few months"

Fig. 1. Eggs of *Pyrilla aberrans* on the stems & branches of *Ficus religiosa*. (Original.)

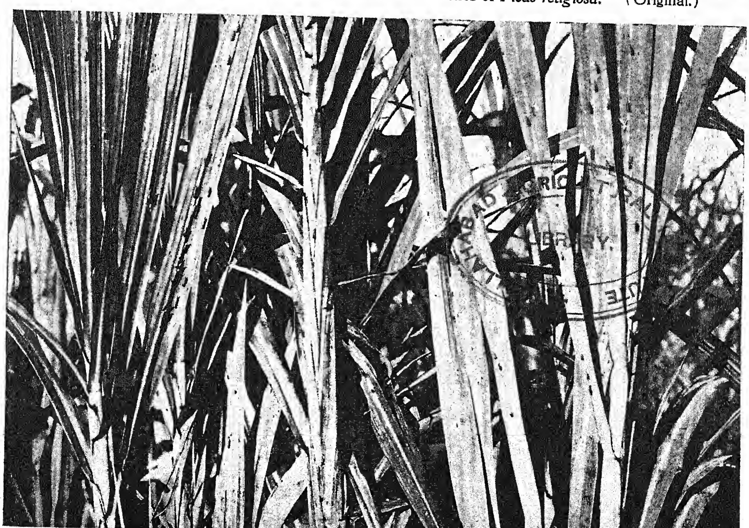
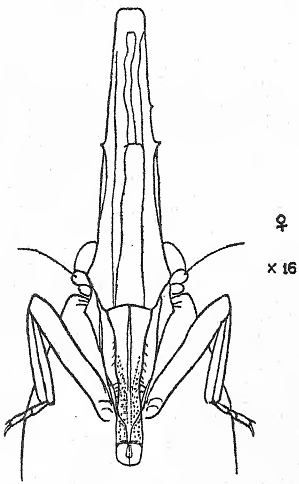


Fig. 2. The Leaf-hopper (*Pyrilla aberrans*) on sugarcane leaves. (Original.)

(*Bull. No. 1, part* 9, *Division of Entomology, Hawaiian Sugar Planters' Association*, p. 271). To such an order belongs the Indian Sugarcane Leaf-hopper, *Pyrilla aberrans*. It belongs to the Family Fulgoridæ, sub-family Lophopinæ. It is pale tawny-yellow in colour and actively jumps about from plant to plant when disturbed (Plate X, figs. 8 and 10). It can also fly short distances to reach adjoining plants. It is injurious both as a nymph and as an adult. The adult hopper has a thick, cylindrical rostrum enclosing four sharp-pointed setæ with which it pierces the tissues of the plant (Figs. 3 and 4). When it settles on the



F G 3. ROSTRUM SHOWING TIP OF SETÆ WITH WHICH THE ADULT PIERCES THE TISSUES OF THE LEAF.

FIG. 4. ROSTRAL SHEATHS SHOWING THE POSITION OF SENSORY HAIRS.

plants to feed, it slides backwards and forwards till it comes upon a suitable place to feed; possibly the suitability of the particular portion of the leaf is conveyed by means of the sensory hairs on the second antennal joint (Plate XVI, figs. 5, 6, 7). In the majority of cases the adults as well as the nymphs prefer to feed on the lower surface of leaves and especially near the bases of leaves near the mid-ribs. It is for this reason that in times of serious outbreaks the entire under-surface of the infested leaves looks whitish-grey owing to the presence of myriads of nymphs, the adults and the innumerable exuvia attached to the leaves. When the nymph or the adult has come upon a suitable place to feed, it settles down and throws out its legs and occasionally the wings are set apart; then the rostrum is pressed close to the surface of the leaf and as soon as a puncture has been made into the tissues of the leaf with the help of the setæ, which are very fine and pointed, the salivary pump is brought into play and a liquid is injected into the tissues which gives rise to irritation or congestion and thus keeps up a supply of fluid at the point operated on. This fluid extends along the grooved setæ by capillary attraction and the rapidity of the current is increased by the pumping action of the pharynx and possibly by the setæ. (Dr. Sharp, *Cambridge Natural History*, Vol. VI, p. 534.) The presence of hairs at the apex of the second joint of the rostrum makes the insertion of the rostral setæ more secure and firm (Fig. 4). The telescopic action of the rostral sheaths and the presence of a large number of stout, sensory hairs externally on them regulates the adjustment of the sheaths and the subsequent suction of the sap above and conveys sensation as to the exhaustion or otherwise of the sap on the spot the hopper is feeding. If therefore the infested leaves are held up against the light they will be found to contain a large number of punctures with yellowish circles around them. It is the coalescence of such spots that imparts a yellowish colour to the leaves which look pale and seared. The result of the drain of an abnormal quantity of plant sap, due no doubt to the presence and consequent feeding of an innumerable number of nymphs and adults, is that the plant sap which would have gone to the nourishment of the leaves and the consequent formation of sugar in the plants is taken into the system of the hopper and exuded as a sweet, transparent liquid known as the honey-dew, which, falling on the leaves below, gives rise to the growth of a black fungus, *Capnodium* sp. It is to lick this sugary excretion that ants, *Prenolepis longicornis*, Latr., *Camponotus compressus*, Fabr., and *Tapinoma melanocephalum*, Tabr., and the wasps, *Vespa orientalis*, L., and *Vespa cincta*, Fabr., are seen in the infested fields. The general result is that the growth of the plants is retarded and they look old and seared prematurely. They, being thus lowered in vitality, probably

fall an easy prey to the attacks of parasitic fungi which complete the destruction begun by the leaf-sucking insects, of which in certain localities and in particular years when the climatic conditions are favourable to its development, the sugarcane leaf-hopper is not the least unimportant. That such is the case elsewhere is also borne out by a remark of the late Mr. G. W. Kirkaldy (*Bull. No. I, part 9, Division of Entomology, Hawaiian Sugar-planters' Association*, p. 271) who said: "It is not alone the exhaustion consequent upon the rapid draining of the plant juices by the Hemipteron's microscopic mouth-setæ that is so deleterious; it is the addition of the horde of fungus spores which often subsequently attack the wounded surface and, quickly multiplying, penetrate into the tissues of the plant, causing decay and death." The crop, surviving an extra virulent attack of the leaf-hopper, is poor both in quantity and quality. The resultant *gur* is insipid in taste and the illiterate cultivator ascribes the loss to the paucity of irrigation at proper times or to the undue prevalence of dry winds. By the above statement I do not mean to say that the poorness of the crop and the resulting out-turn therefrom is solely due to the presence of the leaf-hopper. All that I wish to point out is that in some localities and in particular years the poorness of the cane crop brought about by other factors is accentuated by the presence of the leaf-hopper in abnormal numbers. During the latter part of the year 1912, a large number of adult hoppers was seen swarming with the nymphs of *Dactylopius saccharifolii*, Green. As the leaf-hoppers jumped about freely from plant to plant, the nymphs of the mealy-bug were widely distributed. Thus the hopper at particular times becomes a carrier of other noxious pests and thereby accentuates the damage. It was for this reason that the cane setts which were required for planting by the middle of March of the following year were either wholly rejected and burned or dipped in a strong solution of Crude Oil Emulsion before planting. Since 1906 it has been observed repeatedly that the leaf-hopper prefers broad-leaved succulent varieties to those of thin-leaved less succulent varieties, and it is for this reason that thick varieties like *Samsara*, White *Senna*, *Numali*, Red Mauritius and *Paunda* have been the worst sufferers (see Appendix B).

Distribution of *Pyrilla aberrans* in India.

Bihar and Orissa:	Pusa, Rajputtee, Chapra.
United Provinces:	Cawnpore.
Punjab:	Lahore.
Central Provinces:	Nagpur, Talodi-Balapur (Dist. Chanda), Tharsa (Dist. Bhandara), Raipur.

Bombay:	Bassein, Kasandra (Dist. Ahmedabad).
South India:	Chikkaballapur (Fauna India. Rhynchota, Homoptera, appendix, Vol. VI, p. 85).

Food Plants.

The leaf-hopper prefers sugarcane to any other cereal. When abundant during the years 1906-1907, 1910 and 1914, it was found on Oats (*Avena sativa*), Wheat (*Triticum vulgare*), Guinea grass, Millets, Bajra (*Pennisetum typhoideum*), Kans (*Saccharum spontaneum*) and other long grasses. In the year 1906, when it was extremely bad, the eggmasses were even found on bamboos (*Bambusa arundinacea*), Pipal (*Ficus religiosa*) and other roadside trees. Besides sugarcane, I have only seen it breeding on Juar (*Andropogon Sorghum*) and that was on the Experimental Farm, Cawnpore, in September 1912. The plants, which were in close proximity to the sugarcane plots, contained numbers of nymphs and adults on the lower surface of leaves and these were breeding in numbers. It was also remarkable that in this particular instance there were more hoppers on the Juar (*Andropogon Sorghum*) leaves than on sugarcane. Excepting this, I have never seen it breeding on any other food plant. During November 1912 numbers of adult hoppers were seen resting on the peas (*Pisum sativum*), but were seen not to breed. In March 1913 they were further seen in numbers in wheat and oat fields. At Pusa the hopper is found in numbers on oat leaves especially at the end of March when the cane crop is usually harvested here. During March and April it is also found on Kans (*Saccharum spontaneum*) and other long grasses, but not to any appreciable extent. From these it transfers itself by the beginning of June and begins to breed when the cane is sufficiently high and the plants contain a fair number of green, succulent leaves.

Life-History.

Methods of study. The preliminary efforts to work out the complete life-cycle of the hopper in a working room where the temperature varied considerably from season to season were unsuccessful until solution was found in keeping the leaves, on which the nymphs were fed, green by sticking them up on plasticine in the bottom of broad flat dishes filled with water and tying thin muslin gauze on the top. In this way the leaves remained green from three to four days when the nymphs could be transferred readily to fresh cases similarly prepared. In such cases even the mortality in the nymphs was very great, but successful complete cycles were obtained in most cases. Side by side with rearings in the laboratory,

special field-cages were set up on one or two cane-plants in the fields and half the eggmasses laid on one and the same date were transferred to these cages to see whether the dates of emergence of the adults from the two-halves of the same eggmasses were nearly approximate to each other or not. During 1907, all the rearings were done in the laboratory and, as it was not properly fitted up then, especial precautions had to be taken to keep green the leaves on which the nymphs were feeding and also to maintain an equable temperature within the big cages in which the rearings were done. During 1914, field-cages were set up and one half of the eggs laid within such cages were brought over to the laboratory, the other half being allowed to remain under the cages. The results of the rearings were that in the majority of cases the adults from eggs kept under cages in the fields emerged a little earlier than those which emerged from eggs kept in the laboratory. In two instances the differences between the field and the laboratory emergences of the imagines were not more than from three to five days. In the other five instances the emergences of imagines varied from five to ten days. As the field-cages have a wooden top on them and have wire-gauze screens at the sides, the nymphs and adults breeding within such cages are partially im une from the attentions of parasites and predators and the inclemencies of weather to which they are subject while breeding freely on the cane crop. To breed them entirely in the open, in much the same way as they would have done if left to themselves, was found impracticable as the nymphs, which are very agile, were found to jump out and die.

During the middle of the leaf-hopper season, which in cases of severe outbreaks lasts from July to the beginning of November, it was found that a large number of eggs was parasitized. To obtain an idea of parasitization of eggs, the parasitized eggmasses (Plate X, fig. 3) were frequently collected and brought over to the laboratory where accurate countings of parasitized eggs were made and recorded. When the parasites emerged, a few were kept back for identification and future reference and the remainder were taken over to the sugarcane plots and liberated. Occasionally a number of parasites as they came out of the cage were liberated from the laboratory. Later on when the nymphs and adults appeared stylopised and dryinised, the affected hosts were brought over to the laboratory. From these, adult dryinids were bred out and then ultimately taken back to the fields and liberated there.

The egg. Copulation takes place on the leaves mostly during the day in the usual hemipterous fashion and the female, six to seventeen hours after

copulation during June to August, lays eggs mostly on the lower surface of leaves. When very abundant, as was the case during 1906 and 1907, eggs may be found laid on every part of the plant, the stems, the upper and lower surfaces of leaves and even the trash lying between trenches in the fields. The fertilized female becomes sluggish in her movements and may then be seen with bundles of cretaceous white threads on two thick fleshy pads on the anal end. Having selected the place to lay eggs, she raises herself on her hind legs and stoops down a little. The tegmina are then thrown wide apart and the wings are thrust in between them. The eggs are then extruded and deposited on the leaves. The eggs are laid in rows of two or three longitudinally; sometimes they are as many as four abreast. The eggs nearly touch each other at the sides and the spaces covered by the eggmasses on the leaves vary from 30 to 48 mm. in length and 6 to 10 mm. in breadth, but when laid in a compact single mass its length varies from 10 to 14 mm. and in breadth from 5 to 8 mm. (Plate X, figs. 1 and 2.) Sometimes when the hopper is bad, there may be seen a number of eggmasses either touching or coalescing with each other and in the years 1906 and 1907 the eggmasses in places were from 2 to 5 deep, caused no doubt by a number of females having oviposited at one and the same place. The female, while laying eggs, faces either the apex or the base of leaves on which she lays eggs, but in the majority of cases observed, the eggs were laid with the female facing the apex of the leaves and this explains the reason why, a few days after being laid when the nymphs develop compound eyes within the chorion, all such eyes are in one direction either in a line with the apex of the leaf or its base. When 3, 4, or 5 eggs have been laid the pair of shiny hatchet-shaped claws which are fixed below the anal aperture begin to work and these bring down a sufficient quantity of cretaceous threads from the two thick, fleshy ovoid anal pads fixed on a fleshy peduncle over the anal aperture of the female (Plate X, fig. 11), and strew over the eggs. As soon as the eggs have been covered with a flocculent material, the female moves onwards, extrudes eggs which are caught by the spiny hatchet-shaped claws and laid on the surface of the leaves. When 4-5 eggs have been laid again, the process of covering them with whitish flocculent-insulating material is repeated until the total number of eggs is laid. If, however, some cretaceous white material still remains on the pads above, it is an index that egg-laying has not been finished and that more eggs will soon be laid. The total absence of the whitish material on the pads is an index in the majority of cases that the female has finished egg-laying. The cretaceous white material with

which the eggs are covered is probably intended as a protection against the inclemencies of weather. But it proves no protection against the tiny, active Chalcid parasites which attack the eggs in numbers from August till December. Besides this, the covering of the eggmasses with the cretaceous white flocculent material makes them a very conspicuous object against the greenish background of the leaves, so much so that when once seen they are not soon forgotten, and it is for this reason that the treatment of the pest is facilitated by collecting such eggmasses on the leaves. The coolies, when once shown the whitish patches on the leaves, collect them soon and have no difficulty in spotting such patches on the leaves in the fields.

The number of eggs laid by a female varies greatly. In the undermentioned cases the females were kept separately to note the number of eggs laid by them :—

18th November 1912	53
1st August 1912	49
20th August 1913	49
12th April 1914	22
13th April 1914	49

In one of these cases, on the 20th August 1913, the female began laying eggs at 9-15 A.M. and by 11-10 A.M., 49 eggs were laid on the leaves. She was, however, found dead at 3-30 P.M. the same day. In the fields the counting of eggmasses gave the following results :—

Date	Number of eggmasses counted	Number of eggs in each eggmass	Average
November-December 1907 ...	10	32, 30, 37, 41, 30, 21, 22, 18, 21, 23	27
April 1914	5	25, 25, 24, 24, 49	29
4th August 1914	6	63, 56, 52, 54, 24, 55	50
6th August 1914	3	60, 35, 59	50
17th August 1914	9	51, 39, 49, 50, 50, 49, 37, 55, 51	47
26th August 1914	15	51, 51, 46, 45, 61, 41, 95*, 75*, 49, 89*, 54, 49	47
3rd September 1914	11	37, 49, 57, 58, 50, 40, 63, 40, 30, 51, 56	48
9th October 1914	10	25, 48, 46, 56, 57, 55, 54, 55, 51, 63	51
30th October 1914	12	55, 34, 49, 30, 48, 54, 78†, 48, 36, 47, 50	44
7th November 1914	6	47, 30, 48, 48, 56, 50	46

* In these cases two eggmasses had run into each other.

† Eggmasses coalesced.

Thus the lowest number of eggs found in a cluster on leaves in the cane plantation was 18 and the highest 63, though the usual number of eggs laid by a single female ranges between 27 and 49.

Description of the egg. (146 hours after being laid.)

Each egg is 0·90 mm. long, 0·36 mm. broad, covered with cretaceous white waxy threads from the anal pads of the female. It is cylindrical in shape and rounded at both ends. The chorion is perfectly smooth, covered thinly with a whitish bloom when examined under the microscope. It is slightly curved inwardly in the middle at one side.

When freshly laid it is mellow greenish-grey with one end slightly suffused with pale brown.

Changes in the egg from the time of being laid to the hatching of the Nymph.

14th April 1914	..	.. Eggs laid on a sugarcane leaf at 9-30 A.M. Egg-laying finished by 4-30 A.M., 22 eggs laid.
20th April 1914	Seventh day after oviposition.	Eggs turned light pale yellow in colour. Two brick brown spots have appeared laterally, marking the position of the compound eyes of the nymph within, the other end being slightly suffused with light brown. The space between the two anterior dark brown spots and the posterior anal suffusion light pale green.
21st April 1914	Eighth day after oviposition.	Eggs light yellow in colour with two deep maroon-coloured eyes. The embryo can be seen distinctly in the egg-shell under the microscope, the chorion being finely tessellated with light hexagonal patterns. The body of the nymph within is to be seen distinctly segmented. The brownish suffusion at the other end of the egg-shell represents the brownish colour of the anal end of the nymph within.
22nd April 1914	Ninth day after oviposition.	Eggs light brownish yellow in colour with two deep maroon-coloured eyes at one end with a deep pale brown suffusion at the other end. As the female, while laying eggs, faces either the apex or the base of a leaf, the deep maroon-coloured spots on the chorion, representing the compound eyes of the nymph within, develop in one direction. The eggs lie on the surface of the leaf with the dorsum of the nymph within immediately touching the surface of the leaf, for this reason there are faint corrugations on the upper surface of the chorion enclosing the nymph within representing its legs and antennæ which are folded up on the ventrum. The eggs hatched.

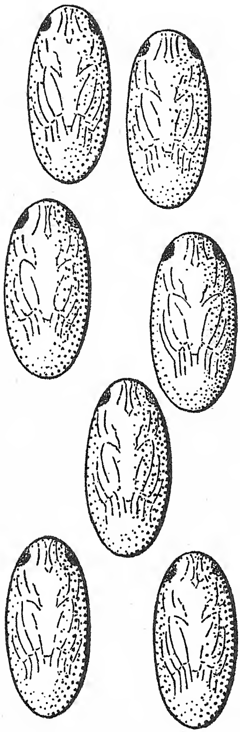


FIG. 5. EGGS OF *Pyrilla aberrans* ABOUT TO HATCH (×30)

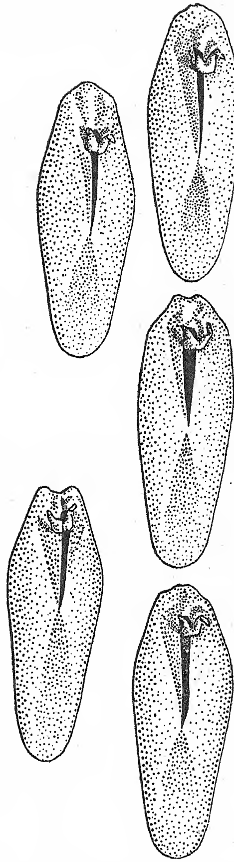


FIG. 6. EMPTY EGG-SHELLS SHOWING ATTACHMENT OF MEMBRANE (×50)

Hatching of the egg and the casting-off of the yolk-skin or membrane.

When the egg is about to hatch, a slit opens anteriorly on the egg-shell to where the two maroon-coloured spots are present, and soon after, the rostrum and the head are thrust out, the yolk-skin or membrane enclosing these parts is pushed down on to the abdomen. The nymph then stands bolt upright in the slit, moves laterally as well as backwards and forwards, trying to extricate its legs. The membrane is then gradually pushed down until it adheres around the abdomen and the legs. In doing so the anterior and the intermediate legs play an important part. The posterior legs, being still within the slit and covered with the membrane, do not move actively. Lateral as well as forward and backward motions continue until the membrane is well pressed down and the legs are entirely free of it. The membrane having now passed over the broadest part of the body, there is very little time taken to extricate the remaining abdominal segments out of it. In a few seconds after this, by the continuation of upward and lateral jerking, the body is entirely free from the membrane which now resembles a shrivelled pellicle, and remains attached to the chorion either entirely within it or attached to the mouth of the slit (Fig. 6).

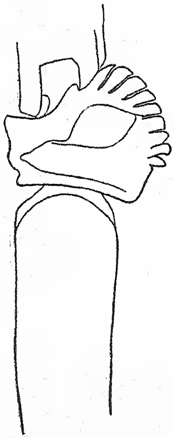


FIG. 7. SERRATED TROCHANTER OF A NYMPH OF *Pyrilla aberrans* TWENTY-FOUR HOURS AFTER HATCHING. [From a mounted specimen in balsam.]

The nymph on coming out of the egg-shell begins to move about on the leaves. After a lapse of 10 to 15 minutes, it stops and begins to feed. Immediately after coming out of the egg-shell it is devoid of the silken threads at the anal end.

In a particular case that was closely watched, the nymph took three hours and a half to get clear of the egg-shell. The dorso-longitudinal dehiscence of the egg-shell is brought about by the presence of teeth on the posterior trochanter of the nymph within (Fig. 7). In a case where the opening of the dorso-longitudinal slit was especially watched under the microscope, it was seen that, prior to the opening of the slit, the hind legs were strained wide apart and the trochanters were seen to rub against the chorion from within. The result was that a slight dehiscence was immediately visible on the egg-shell corresponding to the meso-meta-sternal

areas of the nymph within. This continued to enlarge until it was wide enough to contain the head of the nymph within.

Hatching of the Nymph and its subsequent developments.

14th April 1914..	9-30 A.M.	.. Eggs laid.
22nd April 1914..	7-35 A.M.	.. Eggs began to hatch.
	7-58 A.M.	.. A small slit was found to open on the egg-shell. (This and the subsequent observations refer to an egg especially under observation.)
	8 A.M.	... The slit extended beyond the level of the maroon-coloured eyes and up the vertex.
	8-3 A.M.	.. Vertex, front of head, clypeus, and the rostrum thrust out of the opening.
	8-7 A.M.	.. Slight lateral motion of the body and the head. The legs and the first two abdominal segments out of the slit.
	8-9 A.M.	... Quick throbbing on the point above the clypeus. Lateral motions ceased. Head and body at rest.
		At this time the head, the vertex, the thorax, the abdomen and the legs are shiny, light dull white. Eyes deep maroon, base of rostrum unicolorous with the body. Front of head including clypeus light pale white. Antennal setæ dark grey.
	8-11 A.M.	.. The throbbing on the frons has ceased and immediately after appear translucent lobes on the apex of the vertex and the frons laterally. Lateral motions began, portion as far as the first abdominal segment out of the slit.
	8-14 A.M.	... Antennæ have become well separated from genæ and thrown forwards. Antennæ 2-jointed ending in setæ with fleshy lobes at base having a pair of sensory hairs on them. Apices of spines on posterior tibia black.
	8-16 A.M.	.. Body considerably bent forwards. Abdominal segments seven, distinct, first four shiny white, last three suffused with pale yellow.
	8-18 A.M.	.. Two divided, whitish translucent tubercles appear dorsally on the pronotum, each tubercle being situated on either side of an indistinct dorso-median longitudinal depression. Thoracic segments distinct. Pronotum smallest. Mesonotum slightly longer than pronotum, metanotum the longest. A whitish dorso-median line from anterior part of pronotum centrally to the base of metanotum.
		By this time the crumpled pellicle is to be seen adhering to the end of anal end and lying in the opening of the egg-shell.

22nd April 1914.	8-20 A.M. ..	Two small, deep pale-brown pads have appeared on either side of a central pointed lobe on the anal segment.
	7-35 to 8-22 A.M.	Anal filamentous threads absent. The nymph is completely out of the egg-shell. It lies with its anal end touching the egg-shell.
	8-22 to 8-30 A.M.	Nymph lying motionless with its legs touching the surface of the leaf. Vertex raised up. A thin whitish film visible on the facetted eyes owing to the whitening of edges of each facet of the eye.
	8-34 A.M. ...	Cretaceous threads on anal segment begin to appear.
	8-38 A.M. ..	Legs spread out.
	8-38 to 8-56 A.M.	Anterior part of the metanotum and anterior edges of the second to the fifth abdominal segments turned dark grey dorsally.
	9-5 A.M. ...	Length of cretaceous threads on anal segment 0·24 mm.
	9-35 A.M. ..	Length of cretaceous threads on anal segment 0·36 mm.
	9-45 A.M. ..	The nymph, stationary hitherto, began to move about.

The Nymph two hours and fifteen minutes after the opening of the slit on the chorion.

Antennal joints, vertex, pro- and meso-nota dorso-medianally, metanotum dorso-posteriorly, abdominal segments dorso-basally and laterally, and legs, cretaceous white. Eyes deep maroon with a thin whitish film on them. Antennal setæ, pronotum laterally, base of mesonotum transversely, anterior part of metanotum transversely, the dorso-median region of the first to the sixth abdominal segment, spines to the hind tibia dark grey. Anal segment pale-brown; anal threads cretaceous white.

The Nymph. First Instar. (Forty-eight hours after hatching.)

Length 0·96 mm.; length of anal threads 1·59 mm. General colour milk-white. The vertex, the front of head, the basal antennal joint, the femora and tibiæ white. Pro-, meso- and meta-thoraces, base of abdomen and tarsi light pale-brown. Eyes dark red, antennal setæ and the apex of the rostrum light brown, the anal threads light, greyish white. Vertex slightly produced in front of eyes, face longer than broad, its lateral margins laminately dilated, with a double series of translucent, semi-circular granules.

Thoracic segments distinct, pro- and meso-nota nearly sub-equal, metanotum nearly equal in length to pro- and meso-nota. Anterior margin of pronotum

straight, slightly sinuate behind the eyes laterally ; a series of four globular, translucent spots on either side of the median dorsal ridge running from the middle of the pronotum to the middle of base of metanotum ; mesonotum with two translucent, whitish globular spots on either side of the median dorsal notal ridge in the middle of which there is a raised, fluffy protuberance ; on the metanotum there are two translucent globular spots situated obliquely in the middle on either side of the notal ridge.

Anterior femora and tibiæ broadly ampliated, tarsal joints two, light brown, second longest.

Abdomen distinctly segmented, seven segments discernible, basally pale yellow, apically uniformly suffused with pale orange. The two anal filaments come out of the middle of the last segment. Each filament is composed of a bundle of whitish threads twisted together on which a flossy growth occurs at irregular intervals.

The Nymph. Second Instar. Length from the apex of head to the end of fluffy anal threads 2·82 to 3·03 mm. Length of anal threads 1·26 mm. Length of abdomen (laterally) 0·76 mm., antennæ 0·75 mm. long. Greatest breadth over thorax (on the metanotum dorso-transversely) 0·93 mm.

Front of head, vertex, thoracic segments, legs, antennal joints (excluding the terminal setæ) cretaceous white. Compound eyes deep maroon with a thin whitish film on them and a black speck situated at the interior posterior angle of the eye. The whitish film over the eyes is caused by the walls of the facets being white with the central portion deep maroon. Abdominal segments distinct, the segments being anteriorly pale yellow, posteriorly transversely whitish pale yellow, the last segments deep pale yellow with two fluffy, faint whitish brown rods of threads which curl laterally irregularly. The first abdominal segment transversely smaller than the following segments.

The vertex has a central transverse carina dorsally. The extreme apex of the anterior part is slightly upturned with a double series of small, flat, orbicular translucent tubercles, these being placed on either side of a white faint longitudinal carina, the posterior part being without any ornamentation.

The thoracic segments are distinct dorsally, the pronotum being anteriorly transversely smaller than the following two segments, with two transparent cretaceous white raised tubercles situated medially on either side of the dorso-longitudinal carina extending from the middle of the anterior part of the pronotum and extending down the metanotum.

Antennal joints two with a terminal seta or hair. First joint smallest; breadth 0·015 mm. in the middle and 0·03 mm. at the apex. Second joint 0·15 mm. with fine white, sensory hairs on it all round. The terminal seta is very faint brown in colour and is 3·21 mm. long, basally ending in thick broad sub-globose lobe with a pair of fine, white sensory hairs on it. In this stage the development of fine, white sensory hairs on the second antennal joint is very remarkable.

Femora, tibiæ, first tarsal joint cretaceous white, second tarsal joint pale brown. In the anterior and intermediate legs, the second joint longer than the first. Anterior femora and tibiæ are broad and flat, thickly spined on the upper as well as the lower edges. The intermediate femora and tibiæ are slightly so. The posterior femur is not spined, though the posterior tibia has thin, small, whitish spines on it with eight small, deep brownish black spines at the base, the two anterior and two posterior ones being a little longer than the four central ones.

The Nymph. Third Instar. Length from the apex of vertex to anal end 1·69 mm. Length of anal thread 2·18 mm. Length of vertex 0·46 mm. Breadth at base of vertex 0·21 mm. Length of antenna 0·709 mm. Greatest breadth over metanotum dorsally 0·12 mm.

Vertex, antennæ, and legs white; thorax, abdominal segments 1-4 pale yellow, abdominal segments 5-7 transversely suffused with light brown. Eyes pale green with a black speck on the inner posterior margin; vertex apically upturned with a fine, white longitudinal carination most prominent over the anterior part of the vertex beyond the transverse ridge at about the middle. The second antennal joint is broad and globose, thickly covered with fine white sensory hairs amongst which 5 or 6 olfactory spots are visible from above.

The pronotum is smaller than either meso- or meta-notum which are sub-equal. A medio-dorso-longitudinal carination over the pronotum is continued over the meso- and meta-nota. On either side of this carination there is a pair of opalescent, orbicular spots on the pronotum. On the mesonotum dorso-medially there is a thick, cretaceous white porrect or slightly inclined thread, with a similar one behind it on the metanotum. Anterior femora posteriorly ampliated with a number of fine, white stout hairs. The anterior tibia has similar fine cretaceous white hairs on it. Tarsal joints two on the anterior and posterior legs with stout bent claws with cretaceous white pads below them. On the posterior tibia there are two short, stout dark castaneous spines, one situated a little below the middle, the other a little

above the spinelets at base of tibia. The under-surface of the first joint of the posterior tarsus has a number of sensory hairs on it. There are two small, stout, castaneous spines at the base of the first tarsal joint.

The Nymph. Fourth Instar. Length from apex of vertex to anal end 3·60 mm. Length of vertex 0·57 mm. Breadth at base of vertex 0·27 mm. Length of antenna 0·95 mm. Greatest breadth over metanotum dorsally 1·99 mm.

General colour dull straw colour; eyes pale greenish with a small, dark grey spot at the inner posterior angle; fifth to seventh abdominal segments transversely suffused with light pale brown. Anal thread posteriorly greyish brown; tarsal claws chocolate brown.

Vertex anteriorly upturned transversely divided at about middle with a pair of small roundish opalescent spots on either side of a fine median longitudinal line followed by another pair of spots a little behind the former and immediately approximating to the median transverse suture. The angular speck to eyes formed by the darkening of about 27-32 facets (as seen and counted under the microscope). The second joint of the antenna globose with a number of small, fine sensory hairs all over it, the basal aristal knob nearly sub-globose.

Pronotum smaller than either the meso- or meta-notum with a fine median longitudinal ridge with small light pale yellow orbicular opalescent spots laterally. Mesonotum with a cretaceous white stout thread dorsally on a fine median longitudinal ridge with another similar thread on the metanotum. Tegmina prominent, anterior femora and tibiæ ampliated and sparsely spined both anteriorly and posteriorly; tarsal joints two in the anterior and the intermediate legs, three in the posterior leg, the second tarsal joint of the posterior leg being the smallest, first joint nearly as long as the second and the third together, broad, cylindrical, with nearly the whole of the ventral surface studded with sensory hairs, three spines at end tipped with dark brown. Posterior tibia basally broad with a strong spine tipped with dark chocolate brown at about the middle, with another short strong spine below it immediately above the base having a number of small deep dark brown spinelets.

Abdomen distinctly transversely divided into seven segments, the last three being transversely suffused with pale brown. In some specimens the dorsum, when examined under the microscope, was seen to be covered thinly with a whitish meal.

The Nymph. Fifth Instar. Length from the apex of vertex to end of anal threads 7 mm. Length from apex of vertex to anal end 4·50 mm. Greatest breadth over the thorax (anterior part of metanotum) 2·50 mm.

General colour greyish brown. The frons, the posterior part of vertex and legs translucent white.

Vertex anteriorly upturned, frons laterally ampliated with small, flat, oval, translucent globules at the margin; eyes greyish green with a prominent central black speck; antennal joints white, the second joint elongate, globular studded with sensory hairs, setæ dark fuscous grey.

Thoracic segments distinct; pronotum the smallest, anteriorly excavated behind eyes with two translucent globules and with another row of small globular spots dorsally on either side of a median longitudinal carina; mesonotum longer than the metanotum, greyish brown, posteriorly centrally excavated to fit in the anterior part of the metanotum which is elongate; tegmina distinct, posteriorly reaching the third abdominal segment, base of tegmina pale greyish brown with a black spot at the outer posterior margin, a thin round cretaceous white thread medio-dorsally; metanotum dark brown, posteriorly centrally excavated, wings folded below the tegmina, with a white light brown pencil of threads dorso-medianally, these threads being more curly than those on the mesonotum before; anterior femora ampliated. Tarsal joints two in anterior and intermediate legs, three in the posterior leg. First joint of posterior tarsus nearly as long as the second and third, broad, cylindrical, with nearly the whole ventral surface thickly studded with sensory hairs, three spines tipped with deep chocolate brown at apex.

Abdomen greyish pale brown dorsally, pale orange ventrally, abdominal segments distinct, a pair of light brownish grey woolly threads at the anal end.

Habits of the Nymphs.

The nymphs on hatching remain congregated near the egg-cluster for some time and are devoid of the waxy anal threads which, however, begin to grow out soon after. Three to four hours after hatching the nymphs become active and either sidle about backwards and forwards or jump off from leaf to leaf. They prefer to feed on the lower surface of leaves on or near the mid-ribs, but in serious outbreaks they have been seen in thousands on every portion of the leaf. The nymphs thrust their rostral setæ into the tissues of the leaves and pump out the juice. While thus feeding on the leaves they may be seen wagging their anal threads sideways and exuding the honey-dew in droplets which, falling on the leaves below, gives rise to the growth of a black fungus,

Capnodium sp. The nymph, when about to eject the honey-dew, throws aside the anal sensory threads wide apart and shoots out a droplet of clear, viscid fluid. The nymphs when feeding *en masse* on the lower surface of leaves may be seen doing this with their anal threads stretched out wide apart laterally. The spots where the nymphs feed become yellowish white, and if held up to the light may be seen as little whitish brown punctures on the leaves. If, therefore, a number of nymphs remain feeding on the leaf it becomes pale yellow and prematurely dries up, thereby preventing formation of saccharine matter in the stems. The nymphs of the second, third and fourth instars are not so restless as the nymphs of the first instar. They generally remain feeding on the lower surface of leaves unless disturbed by other nymphs passing by them or the adults hopping about from plant to plant. In the fifth instar the nymphs generally become more active and may then be seen sidling backwards and forwards on the leaves. The nymphs when about to jump off from one leaf to another may be seen to raise their anal threads and to wave them sideways. In no case during the past ten years has a single nymph in any instar been seen parasitized by any Chalcidid. They have been repeatedly seen to be liable to attack by Dryinidæ and Stylopidæ. During August 1906, 1907, 1910 and August to September 1914, numbers of nymphs in every stage of development, but especially the first four instars, were observed to have the characteristic Dryinid swellings on their abdomen. The Stylopidæ confine their attentions to the adults, both male and female and the nymphs, the Chalcididæ to the eggs. It was on the 25th November 1914 that for the first time a nymph of the fourth instar was found to have a male Stylops on the metapleural region and a Dryinid larva enclosed in a bag at the base of the metanotum laterally a little above the place where the cap of the male Stylops was situated. With the exception of this unique specimen, no other nymph has been observed to have both the Dryinid grub and the Stylops (male or female) on it within the past eleven years of observations (1905-1915).

Distinction between the Nymphal Instars.

The distinctions between the nymphal instars are, but for the shape and size, very minute, and the nymphs of the different instars cannot be separated easily by one who has not made a special study of this leaf-hopper. But the difference between the nymphal instars may readily and accurately be fixed by observing the development of the anal segment containing a pair of fuscous, brown rods of cretaceous threads. As already stated above, the nymph on hatching out of the egg-shell is devoid of the anal threads. It is an hour after hatching that the anal threads begin to appear.

The Anal Segment of Nymph of the First Instar. (From a specimen mounted in Xylol Balsam.)

The base of the anal rods of threads is composed of a circular pattern consisting of twelve smaller circles either touching at the rim or partially overlapping each other with an internal transparent area. Within this circular ring there is an internal circular patch with transparences within and bordered on the outside with fine transparent spots, presumably being the bases of setæ which are not discernible, being possibly of the same transparency as the surrounding area. In certain Xylol Balsam mounts, the innermost transparent spot, ending in a fine hair or seta, was not discernible. In others, its vestiges were but indistinctly seen. (Plate XVI, fig. 1.)

The Anal Segment of the Nymph of the Second Instar.

In the anal segment of the nymph of the second instar, to the first circle is added another series of circular patterns touching each other at the edges. In the centre, six circular spots ending in hairs or setæ become prominent. (Plate XVI, fig. 2.)

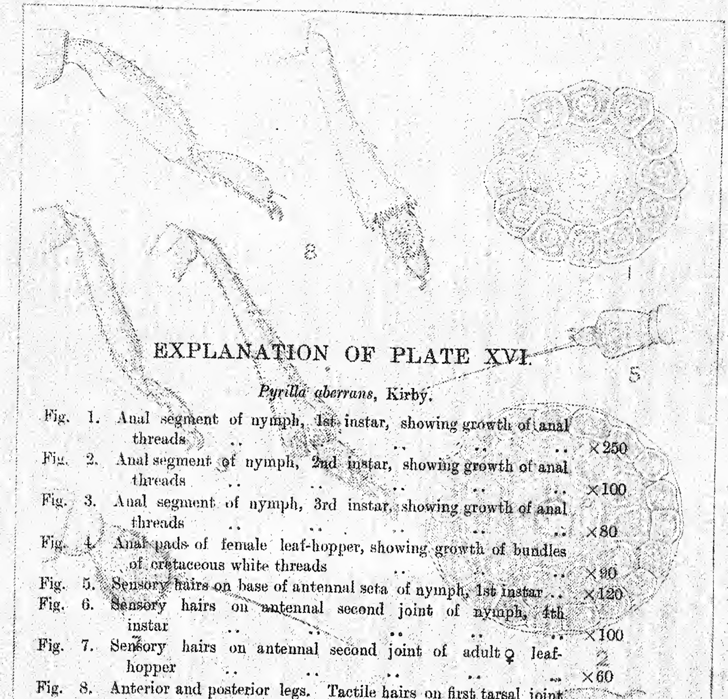
The Anal Segment of the Nymph of the Third Instar.

In the nymph of the third instar, the innermost chain of circular patterns is over-grown with two other chains of circular patterns touching each other at the sides. The six innermost, small, circular spots end in spines, all of which point anteriorly to the centre.

Anal Segment of Nymph of the Fifth Instar.

In the nymph of the fifth instar, to the innermost ring of circles are added four other concentric circles consisting of irregular pentagonal or hexagonal patterns which touch each other at the sides loosely. The pentagonal patterns in the outer ring are rather more compact than those in the inner circles. The central, translucent space is provided with six orbicular spots ending in short, blunt setæ. (Plate XVI, fig. 3.)

Thus, by examining the anal segment of any nymph, its nymphal stage may be determined accurately. From a strictly economic point of view, the determination of nymphal stages is not of much consequence, but when the facts of parasitization are studied it is essential to know the particular stage of the nymphs when they fall an easy prey to the attacks of the Dryinidæ which rarely if ever attack the adults. In some years it was found that the nymphs of the second instar were very heavily dryinized, whilst in other years

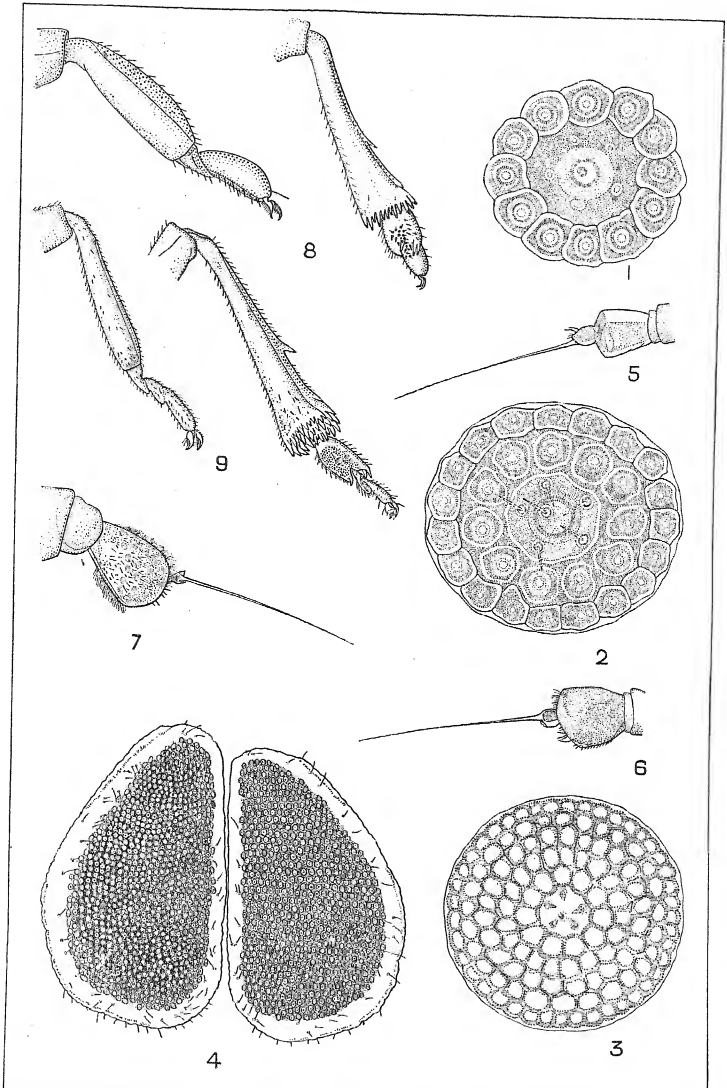


EXPLANATION OF PLATE XVI.

Pyrilla aberrans, Kirby.

Fig. 1.	Anal segment of nymph, 1st instar, showing growth of anal threads	×250
Fig. 2.	Anal segment of nymph, 2nd instar, showing growth of anal threads	×100
Fig. 3.	Anal segment of nymph, 3rd instar, showing growth of anal threads	×80
Fig. 4.	Anal pads of female leaf-hopper, showing growth of bundles of cretaceous white threads	×90
Fig. 5.	Sensory hairs on base of antennal seta of nymph, 1st instar ..	×120
Fig. 6.	Sensory hairs on antennal second joint of nymph, 4th instar	×100
Fig. 7.	Sensory hairs on antennal second joint of adult ♀ leaf-hopper	×60
Fig. 8.	Anterior and posterior legs. Tactile hairs on first tarsal joint of posterior leg	×60
Fig. 9.	Anterior and posterior legs. Tactile hairs on first tarsal joint of ♀ leaf-hopper	×32

PYRILLA ABERRANS.



PYRILLA ABERRANS.

it was noticeable that the nymphs of the third and the fourth instars were the special victims of the Dryinidæ.

The Anal Pair of Pads in the Adult Female.

In the adult female, the anal plate has a pair of thick kidney-shaped, fleshy pieces thickly studded with cretaceous white threads with which the female covers over the eggmasses after they have been laid on the leaves. (Plate X, fig. 2.) When the female has no such threads on the two fleshy pads it is an unmistakable sign that she had laid eggs. The pads when boiled in KOH for a few minutes and passed through the usual mounting technique and ultimately mounted in Xylol Balsam, reveal the presence of innumerable small circles with a speck in the centre. These circles are the bases of cretaceous threads which in a mass appear like a thick whitish rod. The peripheral edges of these rods have no such circular spots and are therefore devoid of the cretaceous threads. Instead of these, there are a few, small whitish setæ mostly inclined outwardly. (Plate XVI, fig. 4.)

Function and Growth of the Woolly Anal Threads in the Nymphal Instars.

No definite conclusions could be arrived at from a series of experiments made to ascertain the exact function of the anal threads. But on the 29th August 1908, it was noticed that, as soon as a female *Dryinus pyrillæ* approached a nymph feeding on a leaf, it began to move its anal threads sideways so briskly that the female Dryinid had to keep off. It was again seen to come near the same nymph and again the same procedure of frightening away the adult parasite was adopted. This time the nymph escaped but another nymph feeding close by it was caught hold of by the female Dryinid in its anterior tarsal claws and oviposition followed. (Plate XVII, fig. 10.) The victim lay paralyzed for a few minutes when it regained consciousness and was seen to limp away on the leaf.

In order to determine the time and rate of development of the anal threads, a nymph of the fourth instar was completely denuded of its anal threads and kept under observation :—

1st December 1914 ..	0-10 P.M.	.. Anal threads completely removed.
	1-10 P.M.	.. A very thin circle of cretaceous white threads has grown at margin of anal segment. The threads were so small that they were hardly measurable.
	4-10 P.M.	.. 0·75 mm. Hairs at margin of anal segment cretaceous white.

2nd December 1914 ..	0-10 P.M. ..	2 mm. Colour of curly threads round the rods of cretaceous white threads, ochraceous brown.
3rd December 1914 ..	0-10 P.M. ..	2·50 mm. Curly threads at base of rods of cretaceous white threads whitish—those towards the apex of the threads, brownish ochraceous.
4th December 1914 ..	0-10 P.M. ..	3·50 mm. Curly threads at base of rods of cretaceous white threads pale white, those in the middle and towards the apex, brownish ochraceous.
5th December 1914 ..	0-10 P.M. ..	4 mm. Curly threads at extreme base whitish, a little above those the curly threads are light pale-green, those at the apex are light greyish ochraceous.
7th December 1914 ..	0-10 P.M. ..	4 mm. The curly threads, round the two rods of cretaceous white threads, are uniformly greyish ochraceous.
8th December 1914 ..	0-10 P.M. ..	4·50 mm. Curly threads uniformly dark, greyish ochraceous.
9th December 1914 ..	0-10 P.M. ..	4·50 mm. Curly threads dark, fuscous ochraceous.
10th December 1914 ..	0-10 P.M. ..	4·50 mm. Same as the previous day.
11th December 1914 ..	0-10 P.M. ..	5 mm. Curly thread dark, greyish ochraceous.
12th December 1914 ..	0-10 P.M. ..	5 mm. Curly threads the same as on the previous day.
14th December 1914 ..	0-10 P.M. ..	5·50 mm. Curly threads dark, greyish ochraceous.
15th December 1914 ..	0-10 P.M. ..	6 mm. Curly threads the same as on the previous day.
16th December 1914 ..	0-10 P.M. ..	6 mm. No change in the colour of the threads.
17th December 1914 ..	0-10 P.M. ..	6·25 mm. No change in the colour of the threads.
18th to 22nd December 1914. ..	0-10 P.M. ..	6·25 mm. No change in the colour of the threads.
23rd December 1914 ..	0-10 P.M. ..	7 mm. Very dark greyish ochraceous.
23rd to 31st December 1914 and 1st and 2nd January 1915. ..	0-10 P.M. ..	No change.
3rd January 1915 ..	0-10 P.M. ..	8 mm. Very dark greyish ochraceous.
9th January 1915 ..	0-10 P.M. ..	Length 9·50 mm. Deep dark greyish ochraceous.
9th to 17th January 1915. ..	0-10 P.M. ..	No change.
18th January 1915 ..	0-10 P.M. ..	10 mm. Moulted in the afternoon. Colour of the curly threads very dark greyish ochraceous.
21st January 1915 ..	0-10 P.M. ..	Length 3·25 mm.

From further experiments made with nymphs of different instars, it was clear that the pair of woolly anal threads drop off with the exuvium at every moult and that fresh threads rise in their place as the nymphs continue to feed and grow after every moult. If, however, the threads are removed intentionally in the middle of the nymphal stages, they again grow up and the nymphs do not appear to be any the worse for the removal. The only difference between nymphs from which the anal threads had been removed and those from which no such threads were removed after a moult, was that the former appeared to be rather more sluggish in their movements on the leaves than the latter which continued to jump briskly from leaf to leaf.

Development of Antennæ and the Presence of Sensory Hairs on the Second Antennal Joint.

In the first instar the second joint of the antenna is robust, being longer and broader than the first joint. It is cylindrical with the anterior end flattened out with small, practically indistinct, fleshy tubercles, from the centre of which rises the knob containing the antennal hair. On the outer side of the knob are a pair of small, bent hairs probably sensory in function. (Plate XVI, fig. 5.) In the second and third instars, the pair of hairs on the antennal knob disappear and small, fleshy tubercles, which by themselves are very indistinct, rise on the surface of the outer flattened end of the second antennal joint. In the fourth instar very fine, small, transparent hairs rise on the top of the outer flattened end of the second antennal joint as well as on its inner edge. (Plate XVI, fig. 6.) In the fifth instar, the second antennal joint is robust and globose with fine, bent hairs on the outer flattened top as well as the inner margin with stout, pointed, transparent setæ in the middle with a number of orbicular translucent spots or shallow foveæ, having from four to six thin fleshy, triangular pointed projections at the extreme outer edge. In a counting especially made from a mounted specimen in Xylol Balsam there were found 17 such orbicular spots on the top of the flattened end of the second joint as well as the sides. In the adult female, the second antennal joint is robust and globose with small, fine bent hairs on the outer and inner margins as well as the top flattened end, the central area being studded with stout transparent, pointed setæ among which are a number of orbicular spots having four to six triangular projections at the outer edge. In this stage the space enclosed within the orbicular spots loses its transparency and it becomes of the same texture as the rest of the joint. A little below the antennal knob at the end of the second joint, there is a pair of small pointed teeth, five to six such teeth being on the outer edge of the second antennal joint and the same number being on the inner edge. (Plate XVI, fig. 7.)

Development of Tarsal Joints and the Presence of Tactile Hairs on the First and Second Tarsal Joints.

The number of tarsal joints in the anterior, intermediate and the posterior legs of the first, second and the third instars is two. (Plate XVI, fig. 8.) In the fourth and the fifth instars the number of tarsal joints in the anterior, intermediate and the posterior legs is two, two and three respectively. In the fourth instar, the third tarsal joint in the posterior leg becomes prominent and remains so in the fifth instar also. In the adult stage, the number of tarsal joints on all the legs becomes three.

In the tarsal joints of the posterior leg of the nymph of the first instar the tactile hairs are mostly present on the apex of the first joint and the base of the second joint, the hairs being specially numerous at the apex of the first joint ventrally. There are no such hairs on the tarsal joints of the anterior and the intermediate legs.

In the tarsal joints of the posterior leg of the nymph of the second instar, tactile hairs are mostly concentrated ventrally towards the apex of the first tarsal joint which is longer than the second joint and globose. In this, as well as in the succeeding third, fourth, and the fifth instars there are no tactile hairs on the tarsal joints of the anterior and the posterior legs.

In the tarsal joints of the posterior leg of the nymph of the third instar, the tactile hairs are exclusively present on the first tarsal joint of the posterior leg. These are mostly concentrated towards the apex of the joint and extend downwards nearly to the base of the joint. (Plate XVI, fig. 8.)

As in the last instar, the tactile hairs on the tarsal joints of the posterior leg of the nymph of the fourth instar, are present exclusively at the apical area of the first tarsal joint, which is robust and globular. The hairs are thickly concentrated on the basal half of apex and extend to about two-thirds the length of the joint, the upper half of the joint being devoid of such hairs.

In the tarsal joints of the posterior legs of the nymphs of the fifth instar, tactile hairs are present exclusively ventrally on the apical surface [illegible] extend down to about three-fourths the length of the first joint [illegible] instar, the number of tactile hairs is considerably larger th[illegible] found in the previous instars. The bases of the ha[illegible] ough not actually touching each other. The basal [illegible] t is free from such hairs.

In the tarsal joi[illegible] e adult female, the number [illegible] sent exclusively on the first tarsal [illegible] robust. The entire ventral surface [illegible] ich are small and pointed and arise out of [illegible] ble when the legs are treated with KOH and pas[illegible] the usual clearing processes and mounted in Xylol Balsam) which nearly touch each other. Only a small, thin, longitudinal ventral fringe is free from such hairs. (Plate XVI, fig. 9.)

The Last Moult.

A nymph when about to moult for the last time becomes lethargic in its movements and ultimately becomes stationary on the leaf. The observations

noted below, relate to a nymph of the fifth instar which was about to moult for the last time. To facilitate observations being made, the nymph, as soon as it had become lethargic, was transferred to a cane leaf placed in a deep circular glass-dish.

22nd May 1914 .. 8 A.M.	..	The nymph transferred to a fresh leaf within a dish.
8-20 A.M.	..	The nymph became stationary, sometimes moving a little sideways.
8-35 A.M.	..	The nymph became stationary, anal threads thrown much wider apart.
8-38 A.M.	..	A longitudinal slit opens on the head and the thorax.
8-40 A.M.	..	The vertex of the adult is pushed out of the slit.
8-45 A.M.	..	Head, vertex and the anterior part of the thorax well out of the dorso-longitudinal median slit. The adult jerks from side to side, then becomes quiet. It now stands at an angle of 135° with the plane of the leaf.
9 A.M.	..	Adult partially out of the exuvium.
9-5 A.M.	..	Adult completely out of the exuvium. Anal pads (♀) white. It remains stationary on the leaf by the side of the exuvium.
9-8 A.M.	..	General colour of the adult milk-white, eyes dark grey, last three abdominal segments transversely suffused with pale orange ; anal pads quite wide apart, of the same colour as the body ; tegmina and wings concolorous with the head and thorax ; legs milk-white extending well beyond the abdomen.
9-25 A.M.	..	The adult female remains stationary at an angle of 135° with the plane of the leaf with its rostrum touching the surface of the leaf, the anterior and the intermediate legs are stretched out touching the surface of the leaf, the posterior legs raised up.
9-45 A.M.	..	The colour of the vertex, the thorax and the tegmina has darkened, and a small greyish streak on the vertex dorsally is apparent.
10-5 A.M.	..	Genæ, clypeus, thorax, and abdomen pale brown, venation of tegmina distinct.
10-45 A.M.	..	The cephalic process apically, as well as laterally, faintly suffused with light grey ; apical area of tegmina with minute dark grey specks.
11-45 A.M.	..	The base of head, thorax, and abdomen light ochraceous ; apical area of tegmina with small dark fuscous specks.
11-53 A.M.	..	The female leaf-hopper now began to move about. The tegmina and the head light ochraceous.

22nd May 1914 ..	12 noon	The apex of vertex, the lateral margins to front of head light fuscous; head, thorax, abdomen, and tegmina dark ochraceous. The female hopper now began to feed on the mid-rib of the leaf and was seen with its rostrum thrust into the tissues of the mid-rib.
	4-45 P.M.	The head, thorax, abdomen, and legs deep ochraceous. Small specks to apical area of tegmina black.

The Adult.

Four to five hours after moulting, the adults are able to move about actively on the leaves. They prefer to sidle about the leaves on both the surfaces and jump about from leaf to leaf. From observations made in the fields at the time of severe outbreaks, it was evident that the adults cannot fly about actively. They can, however, jump actively from plant to plant and as such can transport themselves long distances. During 1906, 1907, 1910 and 1914, when the leaf-hopper was bad on the sugarcane at Pusa, the fertilized females with their distended abdomen could be seen to fly for short distances and then to drop on the ground on account of their weight. It was for this reason that the egg-laying during the hopper-season of 1906 was so abnormal. Bamboos, *Dalbergia sissoo*, *Ficus religiosa*, *Ficus infectoria*, Wheat, Oats, Juar (*Andropogon Sorghum*), Peas, Gram, stones, brick-bats, and practically everything that was near the affected sugarcane plots, were utilized for depositing the eggs. The male is more active than the female. The least touch or disturbance sends the hoppers flying about. They prefer to feed on the lower surface of the leaves, mostly near the mid-ribs. They are very active during the hottest part of the day, 8 A.M. to 4 P.M. when they may be seen flying about actively from plant to plant or from plant to trash lying in the trenches and back again. They congregate in numbers on the lower surface of leaves, when so much honey-dew is exuded that it lies thick on the lower leaves and serves as a nidus for the growth of a black fungus which interferes with the proper function of the leaves. When the honey-dew lies thick on the leaves, ants, especially *Prenolepsis longicornis*, Latr., *Camponotus compressus*, Fabr., and *Tapinoma melanocephalum*, Fabr., may be seen running up and down the plants and licking the sweet excretion. They do not seem to be much attracted to light at night; only a few odd specimens have been seen to come to light, the number being extremely small.

In a case under observation the adults coupled six hours after the last moult. They remained *in cop.* for nearly two hours, when the female began

laying eggs. The time within which the female completes laying eggs on the leaves varies greatly from 23 minutes to as many as 6 hours and in a few cases was seen to extend to as many as 20 to 22 hours.

The male is smaller than the female and has no pair of pads bearing bundles of cretaceous threads at its anal end. This characteristic is so prominent that the two sexes may readily be distinguished from each other in the fields. Even when the female has laid the eggs on the leaves and the cretaceous threads have been us d up in covering the eggs, the distinction between the two sexes remains very prominent. The male genitalia consists of a pair of claspers with a suranal plate. The female has a pair of thick fleshy pads studded thickly with short cretaceous threads at the anal end. (Plate X, fig. 11.) The bundles of whitish threads are so prominent that once seen they cannot be soon forgotten, and this has been the characteristic by which coolies working in the fields have been able to distinguish the females and catch them prior to their laying eggs on the plants. The cretaceous threads disappear from the pads after the eggs have been laid, but still the presence of the pads themselves renders the females quite distinct from the males. The length from apex of the vertex to the apex of the tegmina varies from 11 mm. to 12·5 mm. in the case of the males and 13 mm. to 14·5 mm. in the case of the females. In ten specimens of males and females selected out of a lot of specimens, the lengths were found to vary thus :—

Length from apex of vertex to apex of tegmina.

	♂		♀
1.	11·0 mm.	...	14·0 mm.
2.	11·5 „	...	13·5 „
3.	12·5 „	...	14·0 „
4.	12·0 „	...	14·0 „
5.	12·0 „	...	13·5 „
6.	11·5 „	...	13·5 „
7.	12·0 „	...	13·0 „
8.	12·0 „	...	14·0 „
9.	11·5 „	...	14·5 „
10.	12·5 „	...	14·0 „

Copulation takes place end to end, the vertices of the male and the female being away from each other, and lasts from two to seven hours and in some cases was found to exceed even this. The female after copulation wande s over the plant to select a proper site to lay eggs, the male either remains on the same plant or jumps off on to adjoining ones. The pairs are mostly *in cop.* during the day, especially from 9 A.M. to 5 P.M. The female selects the lower

surface of the leaves, especially near the bases of the leaves and mid-ribs to lay eggs. In fact if a general survey of the position of the eggs laid were made between July and September they will be found to be mostly laid near the bases of leaves, though a few will also be found to be laid some distance below the apices of the leaves. The female prefers to lay eggs by the side of the mid-ribs and very few eggmasses, if any, are seen in the free space between the mid-rib and the edge of a leaf. In years of bad outbreaks practically every part of the plant will be seen to be utilized for egg-laying.

Proportion of Males to Females in a Swarm in the Fields.

From occasional countings made in the infested fields it was evident that the number of females on the leaves was more than the number of males. This may be largely due to the active habits of the male which jumps off from leaf to leaf with the least disturbance (see p. 104). This determination was made from sweepings made with a hand-net at different times of the year :—

	Male	Female	Total
15th November 1912	2	10	12
27th November 1912	11	21	32
1st December 1912	7	26	33
9th January 1913	10	10	20
5th February 1913	8	12	20
19th May 1914	6	8	14
27th May 1914	6	9	15
6th June 1914	4	7	11
13th September 1914	13	22	35

That such is the case outside Pusa was evidenced from a number of specimens received from the Manager, The Kasandra Irrigation and Agricultural Works, Kasandra, District Ahmedabad, Bombay Presidency. The specimens numbered 28 and out of these, 22 were females, 4 males, the rest were mutilated in transit beyond recognition. From 1906 to 1916 several attempts were made to determine the proportion of males to females from clusters of eggs laid by marked females. But all such attempts proved abortive as in no rearing, however carefully it was made, was it possible to rear out in entirety the full number of adults from eggs laid by a female, the reason being that in the early instars the nymphs are very active and hop about from plant to plant or from plant to the sides of the rearing cases and back again. In doing so most of them get damaged and succumb to a premature death. In some cases it was only possible to rear out two adults from an eggmass of 49 eggs on a cane-leaf. If, however, opportunities present themselves again, I hope

to repeat the experiment and determine definitely the relative proportion of males to females reared from an eggmass.

Effect of Climate on the Adults.

During the last three years it has been observed that if hot winds continue to blow for some time during April and May and when the temperature goes beyond 106° F. in shade, the adults are adversely affected and when the hot winds have ceased to blow, the number of adults in the fields will be found to have diminished appreciably. If, however, instead of the hot winds, heavy showers of rain accompanied with high winds and hail fall during April and May, the majority of the adults perish and if a survey is made of the cane-plots after the storm, the number of adults on the plants will be found to have considerably lessened. The sudden change of climatic conditions tells heavily on the adults which cannot withstand the adverse changes. The lessening of the adults at the time precludes the possibility of their gaining a hold on the plants during the succeeding months and the result is either there are no hoppers at all, or if there are, the attack is only a mild one. In one year it was found that there was a large number of adults on the leaves by the beginning of March and eggs were also laid on the leaves. By the beginning of April, egg-laying was general and it was feared that during the following season, July-November, the attack would be a serious one. But by the end of the first week of April, nearly one-fifth of an inch of rain fell, followed a week after by another shower of 1·74 inches. The latter was accompanied by strong winds and hailstones, and a few days after the storm an examination of the cane-plots showed that either the hopper had perished entirely or only a few stragglers were left on the leaves. The plots were bagged by the end of April, and after four hours' work only three adult hoppers were obtained.

In another year there were no showers accompanied by high winds or hail-storms, but hot winds continued to blow for a number of days by the end of April and the temperature in shade oscillated between 105° to 107·7° F. The sudden change of temperature had a disastrous influence on the adult hoppers which either perished *en masse* or their vitality was so lowered that they failed to reproduce sufficiently to cause any appreciable damage to the cane-crop during the following months.

Life-Cycle.

During the latter part of summer and the rains the complete life-cycle of a hopper takes from 46 to 59 days and on an average may be said to last for

52 days. As the cold weather advances the period lengthens and has been found to last from 130 to 136 days. From eggs laid in the middle of December, the hoppers reached their adult stage by the end of March of the following year. The egg-laying begins from March-April and lasts till December and there are from three to four broods during the year, the last laying eggs in December. The broods are not distinct by themselves but run into each other, and it is for this reason that we find hoppers and adults throughout the year on the canes. The first two broods are very distinct, but the last one or two overlap each other and it is at times difficult to differentiate between them. There is no egg-laying during January and February and the beginning of March. In two years, eggs were found to have been laid by the fourth week in March and ceased to have been laid by the third week of December. The hopper attains its greatest development during July-October and then damages the growing cane to an appreciable extent. It is for this reason that canes affected by the hopper at their critical time of growth lose the flowing sap, become pale and sickly and fall an easy prey to other diseases. The ordinary cultivator does not know this and ascribes the pale sickly appearance of the canes to the prevalence of dry hot winds. During 1908, while lecturing at the Agricultural College, Nagpur, I had an occasion to examine the Kachhis' cane-plots at Lendhra near Nagpur with the students and was astonished to see the number of hoppers on the canes and the consequent pale and sickly appearance of the plants. When questioned, the Kachhis (an intelligent and hardy set of cultivators) ascribed the poor condition of the crop to the winds and the paucity of irrigation water. No doubt these factors contributed something to the poorness of the crop, but the main cause, the cane leaf-hopper, was totally ignored. The eggmasses that were found then were heavily parasitized and if the simple expedient of collecting the eggmasses, which is not at all a difficult and tedious process, was known to the cultivators, they would have been able to safeguard the crop from the attack of the insidious hopper.

	Eggs laid	Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Fifth moult of adult
1907-08 ...	19. XI.	3. XII.	25. XII.	16. I. 08.	14. II.	7. III.	28. III. 3. IV.
1914 ...	3. VI.	10. VI.	18-19. VI.	24-25. VI.	2-4. VII.	12-13. VII.	28. VII. 31. VII.
,, ...	6. IV.	14. IV.	23-24. IV.	28-29. IV.	4-5. V.	12-14. V.	22-24. V.

Thus from the above it will be seen that eggs laid during the winter took 130-136 days to mature as adults, whilst eggs laid during April and June took 46, 48, 55, and 58 days to mature.

Another thing noticed while rearing the hoppers, was that there was some variation in the time taken by the eggs to hatch as well as in the emergence of the adult from its last nymphal stage.

Eggs laid	Eggs hatched	Time taken to hatch
1. VIII. (1st eggmass)	8. VIII ...	7 days
1. VIII. (2nd ,,)	10. VIII ...	9 ,,
20. VIII	27. VIII ..	7 ,,
12. IX	21. IX ...	9 ,,
11. VI	20. VI ...	9 ,,
12. VI	22. VI ...	10 ,,
12. IV	22. IV ...	10 ,,
14. IV	22. IV ...	8 ,,

Hibernation.

In this species of the leaf-hopper there is, practically speaking, no hibernation in the proper sense of the term. The hopper is present either as nymph or adult throughout the year. No doubt egg-laying is at a standstill from December to March, but in that period nymphs and adults may be present on the plants though in small numbers. From an abstract of the occasional notes made from 1905-1914, it is evident that in the majority of the years the leaf-hopper had passed through four generations from the end of March to end of November. It was only in occasional years that eggs were found laid late in December and then the eggs were heavily parasitized by *Chalcididæ.* The December parasitization was important and when steps were taken to take advantage of this, the following year the attack of the leaf-hopper was only a light one. The three species of *Chalcididæ* parasitic on the eggs are mostly present from August to December when they disappear or are killed off with cold. From July to September the nymphs are attacked in numbers by two species of Dryinidæ, *Dryinus pyrillæ* and *Chlorodryinus pallidus.* Later on the Stylopid, *Pyrilloxenos compactus,* appears and attacks the adults, both males and females, in large numbers. But in spite of these parasites a few nymphs and adults are always to be found on the leaves in the cold, dull days which prevail at Pusa in the beginning and middle of January. During

February and the beginning of March a number of nymphs are stylopised. A few that escape this fate, turn into adults by the end of March, couple and lay eggs.

ENEMIES.

1. Predators.

The number of predators on the cane leaf-hopper is not very large, and the few seen to prey upon it are not of very great economic importance, as they are unable to reduce or check the pest to an appreciable extent. Of these, *Cremastogaster walshi*, Forel, attacked and carried away the eggs which were laid on the cane leaves within field-cages. On many occasions the ant vitiated the attempts that were made to rear out the adults in the fields from eggs laid on the leaves within field-cages. Otherwise, it is not of much importance. On one occasion (11th August 1908) an Odonate, *Platygomphus dolobratus*, Selys, swooped down upon a female in the act of laying eggs and carried it away. A few days after this (25th August 1908) an Asilid was seen in the fields to pounce down upon a female and carry it away. Spiders do some good by catching the nymphs in their cobwebs and sucking the victims dry. But all the predators put together do not play any significant rôle in checking the pest to an appreciable extent.

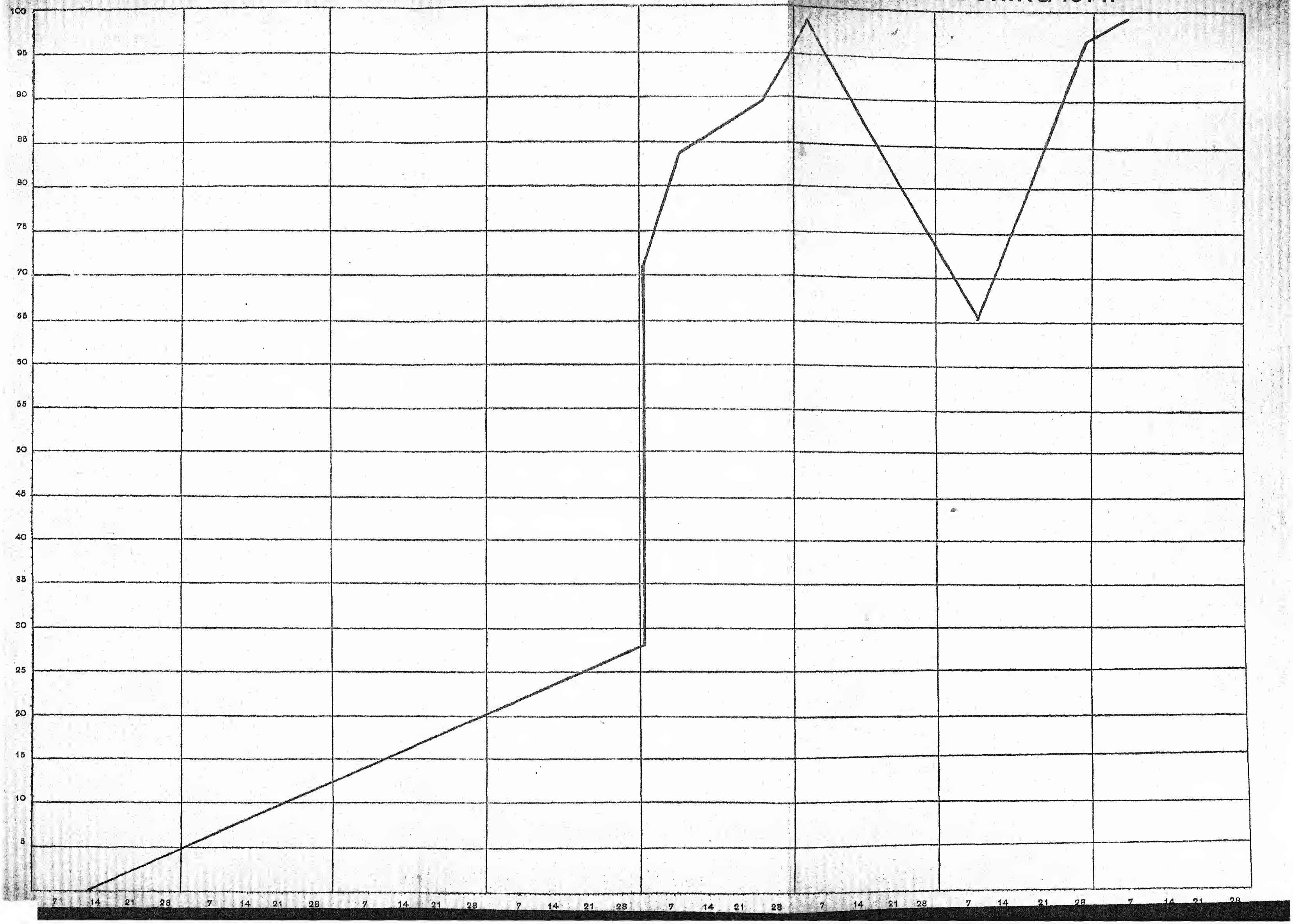
2. Parasites.

(1) *Chalcididæ*.

Of the parasites, three species of *Chalcididæ** play a very important part in efficiently checking the pest. All the three parasites heavily parasitize the eggmasses as they are laid prominently on the leaves. The adult female Chalcid reaches the eggs with her ovipositor and through the whitish fluffy mass with which they are covered. The eggs which escape parasitization retain their natural colour (Plate X, fig. 2), but the eggs which are parasitized soon begin changing colour. At first they become pale fuscous-grey, but darken until they become deep chocolate brown or sometimes dark fuscous (Plate X, fig. 3), and as such are distinctly visible amongst the pale white unparasitized eggs. When the adult parasite (Plate X, fig. 4) is to

* By the courtesy of Dr. L. O. Howard, Chief of the Bureau of Entomology, United States Department of Agriculture, Washington D. C., two of these have been identified by Mr. J. C. Crawford as *Ooencyrtus pyrillæ*, Crawford and *Tetrastichus pyrillæ*, Crawford. The descriptions of these new species will be found in *Insecutor Inscitiæ Menstruus*.

CURVE OF PARASITISATION OF EGGS OF PYRILLA ABERRANS DURING 1914.



come out, it gnaws an irregular hole at one end of the egg-case and emerges. The holes of exit of the adult parasite are not in a line as those of the nymphs of *Pyrilla aberrans,* when they come out of the egg-case, but may be at either end of the egg-shell; thus, in an eggmass consisting of 51 eggs, of which 44 were parasitized, the holes on 14 egg-shells were in one direction, whilst in the remaining 30 they were in the other direction.

The parasites are not present in the beginning when the female leaf-hoppers begin laying eggs on the leaves from the end of March to beginning of April or thereafter. During 1914 when special attention was paid to their appearance and disappearance they were found to be present by the beginning of August and to have reached their maximum development by the first week of November when practically every egg in the egg-cluster on the leaves in the fields was parasitized (see curve). Thereafter with the absence of the eggmasses the parasites also disappeared. That such was not the case only at Pusa, but in other places too where cane was grown on a fairly large scale, is evidenced by the fact that on the 6th October 1914 a number of infested leaves with eggs and adults on them were received from Mr. J. McGlashan, The Central Provinces and Berar Sugar Syndicate Co., Ltd., Sindewahi, District Chanda, C. P., for examination and suggestion of measures to be adopted to check the hopper from damaging the canes. On examination, there were found 3 eggmasses.

		No. of eggs	No. found parasitized a week after receipt	Percentage
6th October 1914	1	45	45	100·00
	2	54	26	48·14*
	3	48	48	100·00

* Only two hoppers emerged out of 54 eggs. The rest were damaged in transit, but from their appearance it was evident that the whole eggmass was parasitized.

PARASITIZATION OF EGGMASSES OF *Pyrilla aberrans* DURING 1914.

(*In taking percentage of parasitization in column 5, decimals have been left out of consideration.*)

Date	No. of eggmass	No. of eggs in the eggmass	Number of eggs parasitized: 1st day after collection	2nd day after collection	3rd day after collection	4th day after collection	5th day after collection	6th day after collection	7th day after collection	Per cent. parasitized	Mean percentage	Remarks
11th April 1914.	1	25	...	...	...	...	...	...	...	...	...	None parasitized. From all the egg-masses nymphs hatched out.
	2	25	...	...	...	...	...	...	...	...	...	
	3	24	...	...	...	...	...	...	...	...	...	
	4	24	...	...	...	...	...	...	...	...	...	
	5	47	...	...	...	...	...	...	...	...	...	
1st August 1914.	1	63	...	...	...	9	24	25	25	39	23·16	
	2	56	...	...	...	...	...	...	...	0		
	3	52	...	...	...	16	19	22	22	42		
	4	54	...	...	...	...	22	22	22	42		
	5	24	...	...	...	...	...	...	...	0		
	6	55	...	...	...	...	9	9	9	16		
8th August 1914.	1	60	...	...	30	37	37	53	53	88	76·63	
	2	35	...	...	4	7	23	23	23	65		
	3	59	...	...	...	...	37	46	46	77		
17th August 1914.	1	51	...	35	47	47	49	49	50	98		
	2	39	...	19	22	24	26	30	30	92		
	3	49	49	49	49	49	49	49	49	100		
	4	50	37	39	39	39	41	50	50	100	83·77	
	5	50	24	34	34	34	42	49	50	100		
	6	49	47	47	47	47	47	47	47	95		
	7	37	28	28	28	28	28	28	28	75		
	8	55	53	53	53	53	53	53	53	96		
	9	51	...	21	24	24	30	48	50	98		
26th August 1914.	1	51	32	38	38	41	46	50	50	98	89·70	
	2	51	19	27	41	51	...	...	51	100		
	3	46	30	31	...	...	...	...	31	67		
	4	45	...	17	19	21	24	31	31	97		
	5	61	27	36	41	48	54	61	61	100		
	6	41	20	24	27	29	40	...	40	97		
	7	95	71	73	81	88	93	95	95	100		
	8	75	60	60	72	72	...	...	72	97		
	9	49	37	44	48	...	...	...	48	97		
	10	89	49	51	62	66	66	...	66	74		
	11	54	30	37	41	41	47	49	54	100		
	12	49	12	30	37	39	39	45	49	100		

26th August 1914. (Contd.)	13	44	21	34	38	33	39	42	42	95	89·70	
	14	11	...	..	4	4	7	11	11	100		
	15	56	38	41	41	47	49	...	49	98		
	16	22	7	9	9	11	14	..	14	63		
	17	33	4	8	8	12	12	14	14	42		
3rd September 1914.	1	37	...	...	27	34	37	...	37	100	98·70	
	2	49	49	...		...	...	...	49	100		
	3	57	...	...	21	37	42	54	55	96		
	4	50	50	...		...	...	...	50	100		
	5	40	..	11	23	24	29	36	38	95		
	6	63	59	...	61	...	...	...	61	96		
	7	40	40	...	...	..	...	...	40	100		
	8	30	..	7	16	21	27	30	30	100		
	9	51	51	...	...	...	...	...	51	100		
	10	56	56	...	...	...	...	...	56	100		
9th October 1914.	1	25	4	*	*	4	*	*	4	16	65·30	* No observations were made on 2nd, 3rd, 5th and 6th day after collection.
	2	48	13	...	...	13	..	...	13	27		
	3	46	29	...	...	29	...	...	42	91		
	4	56	38	...	...	39	...	...	49	87		
	5	57	48	...	...	52	...	...	54	94		
	6	55	21	...	...	54	...	...	54	89		
	7	54	21	..	...	21	..	...	21	38		
	8	55	43	...	...	43	...	...	47	85		
	9	51	33	...	...	40	...	...	43	81		
	10	63	22	...	...	23	...	...	23	36		
30th October 1914.	1	55	...	...	17	29	40	51	54	98	91·63	
	2	34	...	6	19	27	30	34	34	100		
	3	49	...	17	29	40	46	...	46	93		
	4	30	...	6	11	19	27	30	30	100		
	5	48	...	11	29	37	40	40	42	87		
	6	54	4	19	33	39	46	52	54	100		
	7	78	...	27	39	51	63	73	73	96		
	8	48	...	9	20	33	46	46	48	100		
	9	36	29	...	..	...	...	...	29	80		
	10	47	...	13	22	29	33	24	37	78		
	11	50	...	12	23	33	...	...	33	66		
th November 1914.	1	47	...	...	...	...	...	47	47	100	99·33	
	2	30	...	...	...	...	...	29	30	100		
	3	48	...	...	...	..	...	32	48	100		
	4	48	...	...	...	...	...	42	48	100		
	5	56	...	...	...	...	...	54	55	98		
	6	50	...	...	...	...	..	46	49	98		

The parasite (Plate X, fig. 4) was present late in 1906 and 1907 and was also present during the latter part of 1908. During 1914, the Chalcid, which was present during 1906 and 1907, was conspicuous by its absence and its place was taken by two other Chalcididæ which by the first week of November parasitized almost all the eggs in an eggmass. Advantage was, therefore, taken of the presence of the parasites and everything was done to circumvent the progress of the leaf-hopper by collecting the parasitized eggs, breeding out the parasites therefrom and liberating them in the cane fields. The egg-masses, as they were collected from the fields, were put in earthen receptacles covered with cheese-cloth (Fig. 11) the meshes of which were sufficiently wide to allow the parasites, but not the nymphs, to escape through them. This work was continued throughout the hopper-season, July-November, and was stopped when no more eggmasses could be found on the plants by the third week of November, 1914.

When the Chalcididæ had disappeared, a large number of nymphs and adults was found stylopised. In the adults, the number of Stylops present in the abdomen, mostly ventrally, varied from 1 to 12, whilst in the nymphs the number varied from 1 to 7. Along with the Stylops, the nymphs were parasitized by the Dryinidæ, *Chlorodryinus pallidus* and *Dryinus pyrillæ*. By the middle of November 1906 and 1907, *Dryinus pyrillæ* appreciably diminished, though *Chlorodryinus pallidus* continued to parasitize the nymphs till late in January 1915. After the Dryinidæ, the Stylops appeared, but in some years they appeared with the Dryinidæ.

In the nymphs, both the female Stylops, *Pyrilloxenos compactus* as well as the grubs of *Chlorodryinus pallidus* and *Dryinus pyrillæ* were present. The Stylops was present on the abdomen ventrally whilst the bags enclosing grubs of the Dryinid were present laterally on the meto-pleural region of the nymphs. By the presence of the Stylops the females become sluggish and seem to lose their former agility, the presence of the Dryinid grubs seemed to have no marked effect on the *Pyrilla* nymphs until the bursting of the sac containing the grub and the ultimate death of the host, which either remained fixed on the leaf or was blown off by the wind.

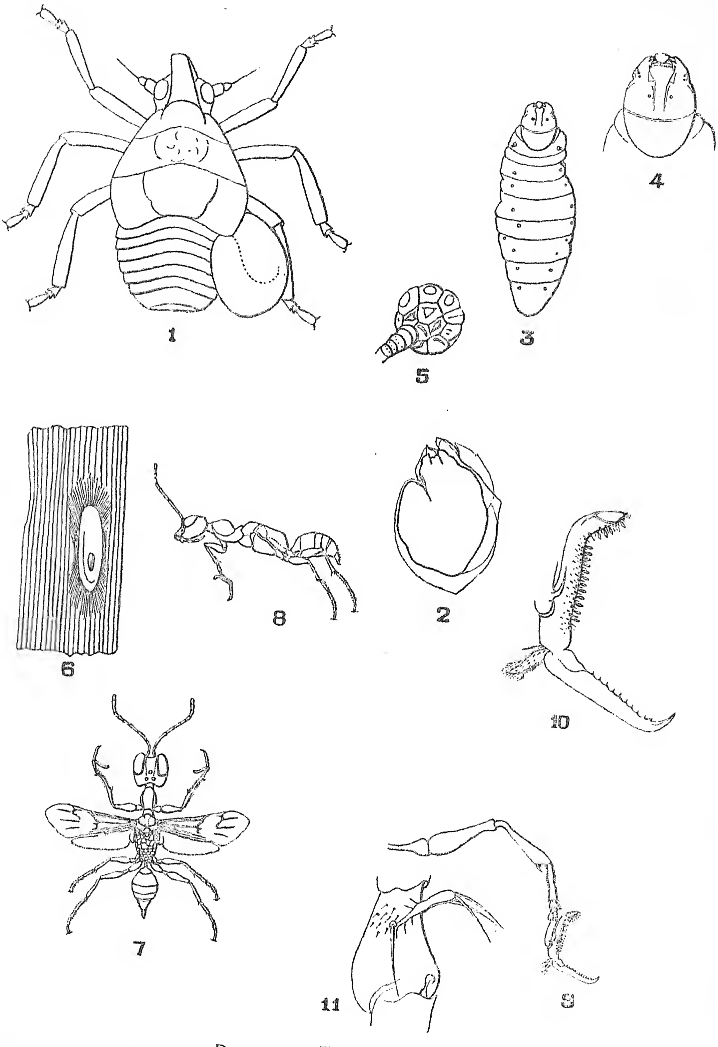
(2) Dryinidæ.

Next to the three Chalcididæ, the two species of Dryinidæ, *Dryinus pyrillæ* and *Chlorodryinus pallidus*, play a very important part in checking the sugarcane leaf-hoppers, *Pyrilla aberrans*, *P. perpusilla*, and *P. pusana*, from seriously damaging the canes at Pusa. During 1906 and 1907, *D. pyrillæ* was

EXPLANATION OF PLATE XVII.

Dryinus pyrillæ, Kieffer.

Fig. 1.	Nymph of *Pyrilla aberrans*, showing position of the sac of the parasite, dorsal view	..	×3?
Fig. 2.	Sac teased out of the body of the host, showing the grub inside (details given from high magnification)	..	×12
Fig. 3.	Grub taken out of the sac, dorsal view	..	×25
	(From a mounted specimen on slide in Xylol × Balsam).		
Fig. 4.	Mouth parts of the grub much magnified	..	
	(From a mounted specimen on slide in Xylol × Balsam).		
Fig. 5.	Thoracic stomata of the grub much magnified	..	
Fig. 6.	Pupa of the grub on a piece of sugarcane leaf	..	
Fig. 7.	*Dryinus pyrillæ*, Kieffer ♀ dorsal view	..	×12
Fig. 8.	*Dryinus pyrillæ*, Kieffer ♀ side view with the wings removed. Showing maxillary palp and the labial palp	..	×12
Fig. 9.	*Dryinus pyrillæ*, Kieffer ♀ anterior leg showing tibia, tarsus and the tarsal claw	..	×20
Fig. 10.	*Dryinus pyrillæ*, Kieffer ♀ anterior tarsal claw	..	×60
Fig. 11.	*Dryinus pyrillæ* Kieffer ♀ third tarsal joint	..	×200



Dryinus pyrillae, Kieffer.

present but during 1914-15, *C. pallidus* heavily parasitized the nymphs mostly of the 2nd, 3rd, and 4th instars. From the 3rd week of October 1914 to the middle of January 1915, *C. pallidus* parasitized from 7 to 10 per cent. of the nymphs then present on the leaves. During 1914, *D. pyrillæ* was conspicuously absent and no specimen of it was found. It was, however, found again during August-September 1915, but in very small numbers.

(a) *Dryinus pyrillæ*, Kieffer.

Lesto-dryinus n. n. für *Dryinus* Latr. *pyrillæ* sp. n. (Kieffer), Bull. Soc. Metz., 27, Habitat—Bengalen; Zoological Record, 1911, Insecta, p. 277; Indian Insect Life, p. 171.

(Plate XVII, figs. 1-11.)

A single grub of this species was first found by me on the 16th August 1907. The sac, enclosing the grub, burst open the following day and the grub moved down nearly 170 mm. on the leaf and began spinning a whitish, elongate flat cocoon. (Plate XVII, fig. 6.) After spinning the outer cover it span the inner cocoon and rested for two days when it pupated. The adult came out after making a clean, circular hole in the cocoon and immediately flew away. The adult females are very active and may be seen actively flying about the leaves, occasionally settling down, especially near the nymphs, and then flying away. The adults are prominent mostly during the hottest part of the day and in this species the adults were seen in the fields mostly from August to November 1907. No trace of these was found from 1909-1914. The grubs as well as the adults were, however, again seen during August-September, 1915. During 1915, as well as in 1907, the dryinid grubs were found on the nymphs which were mostly in the second to fourth instars. Along with the dryinid grubs there were also female Stylops in the abdomen ventro-laterally.

(b) *Chlorodryinus pallidus*, Perkins. (Plate XIX, figs. 5-7).

The adult specimens were bred out from nymphs of *Pyrilla aberrans* from November 1914 to the middle of January 1915. The specimens were identified by Mr. S. A. Rohwer of the United States National Museum through the courtesy of Dr. L. O. Howard and Mr. J. C. Crawford who, while returning the identified specimens, said: ".............They have been named by Mr. S. A. Rohwer as *Chlorodryinus pallidus*, Perkins, with the remark that they agree well with the description of that species, but that the Perkins specimens came from Australia.

"To this comment of Mr. Rohwer's I will add that the exchange of commerce between these two regions would in all probability carry such injurious insects and their parasites back and forth."

The species has hitherto been recorded from Australia and is now for the first time recorded from India where it occurred in large numbers from the beginning of November 1914 to the middle of January 1915. The adults could be seen flying about the fields, occasionally resting on the leaves, then flying off and pouncing upon an unwary nymph which was caught in the anterior claws (Plate XIX, fig. 7) and parasitized. The nymph that fell a victim to the attack of the female Dryinid remained stunned and fixed on the place it was caught by the female Dryinid for a few minutes, wagged its anal threads and then became somewhat active. At least, from the third week of November to the end of December 1914, numerous nymphs of *P. aberrans* were to be seen with the bags of the Dryinid on the metanotal pleural region. In some cases the position of the bag varied slightly; in such cases the bag enclosing the parasitic grub was placed a little further up the metanotal basal region between the junction of the metanotal and the first abdominal somites. At first, the *Pyrilla* nymph continues to move and jump about as if nothing had happened to it, but soon after when the grub within it becomes full fed, it becomes lethargic, loses its former agility, becomes stationary on the leaf with its intermediate and posterior legs well spread out. Soon after, the sac enclosing the Dryinid grub within dehisces and a whitish, apodous, elongate, cylindrical grub comes out.

At first the sac dehisces from below upwards to about two-thirds its length, represented by the abdomen and a third portion of the thoracic region. A few seconds after, the dehiscence increases and the grub comes out of the sac. In some cases the grub was seen to commence spinning the cocoon immediately after coming out of the sac. In other cases, the grubs moved down the leaves, distances varying from 20-30 to as much as 170 mm. The parasitic grub when coming out of the sac enveloping it, expands and contracts its body-segments and the host wags its anal processes and sometimes feebly moves out its anterior and intermediate legs. This is continued for 30-40 minutes and the mouth-end of the grub comes out first. As soon as this touches the plane of the leaf, the host ceases to wag its anal threads and dies. As the posterior portion of the parasitic grub still remains within the sac, and as the grub continues to move about its mouth laterally, the result is that in some cases the host is pitched high on the posterior end of the grub and continues to remain in this position until the grub is completely out of the sac. With

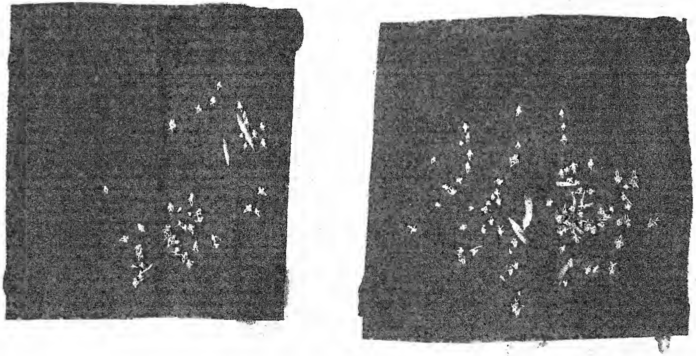


Fig. 8. Pupae of *Chlorodryinus palildus Perkins* amidst nymphs and their exuvia on the sugarcane leaves. (Original.)

a few, lateral, sharp jerks the empty body of the host is thrown away to a distance of 5 to 7 mm. In a case that was specially watched, a parasitic grub took one hour and twenty minutes to come completely out of the sac on the body of a nymph of *Pyrilla aberrans.*

The shape of the sac enveloping the parasitic grub within is like that of a Sann-hemp (*Crotalaria juncea*) seed. It is dark-grey in colour, and in some cases varies greatly, with ten to eleven transverse, dull-white bands which are visible under a magnification of ten diameters, otherwise when looked at from a distance it is smoky grey in colour.

The grub. (Description of a grub taken out of the cocoon.)

Length 4·38 to 4·52 mm., greatest breadth over abdomen dorsally 1·44 to 1·50 mm., general colour whitish-lilac, especially in the abdominal region; head chitinous, pointed; front of head broad at base, pointed anteriorly with four small whitish hairs in the middle; clypeus chitinous, pale-brown anteriorly, laterally dark fuscous with six small, greyish porrect hairs on the anterior margin; mandibles strong and powerful, dark brownish-ochraceous, cleft in the middle; maxillæ small, anteriorly pointed, of the same colour as the front of the head; maxillary palpi stump-shaped with four small hairs at the end; labium broad and flat extending beyond the labrum and is the most active organ. It directs ultimately the position of the sticky translucent saliva which on coming in contact with the air forms fine white strands of silk which form the cocoon. It is anteriorly dark fuscous, with small whitish hairs on the margin as well as in the middle.

The cocoon. The cocoon is made up of thin, whitish, silken strands exuded by the full-grown larva from its mouth. It is shiny white when seen under a magnifier magnifying ten diameters and is in the form of an inverted hammock with the edges touching the edges of the leaf. The extreme length of the cocoon is 9 mm. It encloses within it a smaller cocoon which is 4·50 mm. long and 0·60 mm. broad. Within this internal cocoon the grub may be seen either lining the cocoon from within or resting within it prior to pupation.

The texture of the cocoon is so thin that the grub, as well as its movements within, can be seen with a magnification of ten diameters.

Against the greenish background of a sugarcane leaf, the cocoon forms a conspicuous object and as such may be easily collected even by laymen. At first its colour is whitish, slightly tinged with green, but later on it becomes tinged with brown. The cocoons are generally found where *P. aberrans* nymphs congregate to feed and to moult and it is not unusual to find them mixed up with débris, exuvia and the remains of the parasitized nymphs. (Plate XII.)

Distinction between the Male and the Female Cocoons. The distinction between the male and the female cocoons is very prominent. The male cocoon is smaller than the female cocoon. Besides this, the male pupa turns shiny jet-black within the cocoon, some time before the emergence of the adult. The female pupa turns brick-brown with small streaks of dark-grey on the thoracic regions, laterally as well as centro-dorsally on the abdomen; the eyes being jet-black form conspicuous objects within the cocoon against the general brick-brown colour of the rest of the body. The female pupa is more active than the male pupa within the cocoon, and the least touch or disturbance causes the former to gyrate on its anal end within the cocoon. On these distinctions a number of cocoons were separated, and from every one of them the sex emerged as was expected. As the cocoons are spun invariably on the leaves it was not possible to mark the habits and changes in colour, etc., of the pupa within the cocoon. To record definite observations, a grub as soon as it came out of the sac was put on a glass slide to pupate and spin the cocoon and it was thus possible not only to mark the colour changes but also to note the habits of the pupa within.

Description of the female pupa shortly before the emergence of the adult. (Dorsal view—For purposes of description, the pupa was teased out of the cocoon.)

Length 3·18 mm. Breadth over head 0·84 mm. Greatest breadth ove the thorax 0·96 mm., greatest breadth over abdomen 0·93 mm., length of abdomen 0·16 mm., space between the eyes anteriorly 0·42 mm.

Space between the eyes on the vertex, thorax, abdomen, front femora, scape of antennæ pale green; eyes and ocelli light castaneous; front of head including clypeus pointed anteriorly; antennæ reaching meso-sternum laterally. Eyes elongate oval, somewhat depressed in the centre; ocelli concolorous with the eyes, placed triangularly on the front of vertex; pronotum about half as broad as the mesonotum, transversely round; anterior femur obliquely raised forward, its apex nearly reaching the eyes. Anterior half of mesonotum bright pale green; pleural region including the tegula suffused with light fuscous. Metanotum bright pale green, pleural region being suffused with light fuscous in continuation of the mesopleural coloration. Wing pads longer than broad, pale green, the apices of the posterior wing reaching the base of the first abdominal segment. Between the wing pads and the first abdominal segment the intermediate pair of legs is thrust in, the apex of tibia reaching the base of the metanotum immediately near the pleural fuscous suffusion, the apex of tarsus reaching the base of the second abdominal segment. Abdominal segments

nine, distinct; the third, fourth, fifth, and the anterior half of the sixth segments dorso-centrally suffused with dark fuscous; the apex of posterior tarsus reaching the base of the eighth abdominal segment.

Emergence of the Adult from the Cocoon. The adult when about to emerge squirms within the cocoon and then bites off the portion lying immediately over its mouth with its mandibles. The portion thus bitten off is either square or oblong and in some cases is so small that it soon separates from the cocoon and falls off, but in the majority of cases the piece cut off remains attached to the orifice through which the adult, either male or female, comes out. The adult on coming out of the cocoon is so active that it does not rest on the cocoon but straightaway flies off and rests on the sides of the breeding cage.

Detailed observations on a grub from the bursting of the sac to pupation and the ultimate emergence of the adult.

7th December 1914	11-50 A.M.	Sac opens in the middle.
	0-10 P.M.	The sac widens and the middle of the abdomen is out of the opening.
	0-50 P.M.	Mouthparts out of the sac.
	1-10 P.M.	Grub completely out of the sac.
8th December 1914	0-30 P.M	Outer cocoon completed. Grub resting. Head, thorax, very pale yellow, abdomen pale orange.
9th December 1914	3-40 P.M.	Grub resting. Head and thorax, pale yellow, abdomen pale brown.
10th December 1914	3-40 P.M.	Grub resting. Head and thorax pale green, rest of body light pale brown.
11th December 1914	3-40 P.M.	Grub resting. Light yellowish-green, somewhat darkened in the middle owing to body contents within.
12th December 1914		Grub resting, occasionally moving the mouth from side to side, pale green in colour.
13th December 1914		Grub resting. Colour pale green.
14th to 16th December 1914.		Grub resting.
17th December 1914		Grub pupated. Body pale green, eyes and base of anal end, pale brown.
19th December 1914		Eyes pale brown, body pale green.
21st December 1914		Eyes pale ochraceous, body pale green.
25th December 1914		Eyes pale ochraceous, body pale green, first three abdominal segments light grey, lateral ends of mesonotum dark-grey.
27th December 1914		Eyes pale ochraceous, body pale green, two oblique angular, dark fuscous streaks on base of mesonotum laterally; a dark spot on base of abdomen extending to about middle dorso-longitudinally.
28th December 1914		The markings noted above have darkened in colour.
3rd January 1915		Eyes black; head, thorax, and abdomen light greenish brown, mesonotum laterally suffused with black.

6th January 1915	Eyes deep black, head, thorax bright pale orange; two small oblique black patches on mesonotum dorsally with a small, dark fuscous transverse streak in front of them. Wing pads dark grey, pressed to metathorax; abdomen pale green, dorsally suffused with light fuscous.
9th January 1915	Same as on 6th January 1915, the antennal joints have darkened in colour basally.
14th January 1915	Female emerged.

The female (Plate XIX, fig. 6) is longer than the male (Plate XIX, fig. 5) and is bright stramineous-brown in colour. The head, thorax and abdomen of the male are jet-black, the legs being pale stramineous. The antennæ in the male are eight-jointed, those in the female are ten-jointed. In the male the anterior tarsi, like the intermediate and posterior tarsi, are five-jointed. In the female, the fifth joint of the anterior tarsi is modified into claspers (Plate XIX, fig. 7), one arm of which is toothed, the other being provided with raised projections to receive the teeth when at rest. It is with these claws that the female lacerates the tissues of the hosts and therein deposits its egg. It is the female which is mostly in evidence in the fields when the leaf-hopper is present in numbers on the canes. The male is rarely seen about in the infested fields. The female is so unlike the male in colour, habits, and structural details that there is very little difficulty in differentiating it when once both the adults have been seen.

The female *Chlorodryinus pallidus* parasitized the nymphs only and in not a single case was an adult male or female hopper seen with the characteristic sac of the Dryinid grub on its body. The female Dryinid confines its attention exclusively to the nymphs which were also parasitized by *Pyrilloxenos compactus* at one and the same time. Thus, some of the nymphs had only the Dryinid grubs in them, some had only Stylops in them, whilst others had both the Stylops and the Dryinid grubs in them. The number of female Stylops on a nymph varied from 1 to 7, but excepting in one solitary instance when on the 1st December 1914, two grubs were found on a nymph, in no other case was more than one Dryinid grub seen on the body of a nymph. No adult leaf-hopper was seen to be parasitized by the Dryinid. The nymphs of the leaf-hopper did not seem to be any the worse for the presence of the female Stylops on them. It was only when the male Stylops emerged that the adult leaf-hopper seemed to be prostrated and ultimately died. In the early stages of development of the Dryinid grub, the nymph, though sluggish in its movements, is able to hop about from plant to plant. It is only when the sac containing the parasitic grub within dehisces, that the nymph succumbs.

The stylopised nymphs could be distinguished readily from those dryinised by the presence of small, cylindrical, jet-black tubes on the abdomen ventrally. The dryinised nymphs had dark grey kidney-shaped sacs jutting out of the metapleural areas. In no case was a Dryinid grub found on the abdomen ventrally or a Stylops on the thoracic dorsal, sternal, or pleural region.

Parasites on the æstivating Grubs and Pupæ of Chlorodryinus pallidus.

When a large number of nymphs of *P. aberrans* were parasitized by *Chlorodryinus pallidus*, a few æstivating grubs and pupæ of the Dryinid were found parasitized. The hyperparasitization was noticed for the first time on the 7th December 1914, and was found to last till practically the end of January 1915 (27th January 1915). Within the innermost pupal chamber three to seven grubs of the hyperparasite were found lying immediately in contact with the host. The usual number to be met with was three or five but in a few odd cases this number went up to seven. That these grubs are cannibalistic in habit was noticed for the first time on the 8th December 1914, when a cocoon of *C. pallidus* bearing three grubs of the hyperparasite was put in a dish for the adult hyperparasites to emerge. The following day, *i.e.*, on the 9th December 1914, only two grubs of the hyperparasite were found together with the mutilated remains of the third lying between the two, one of which had become very plump and sleek, no doubt having messed on its companion. Both the grubs pupated within the inner cocoon of the Dryinid, *C. pallidus*. But prior to pupation each hyperparasitic grub exuded small, cylindrical pellets of excreta, of a deep castaneous-brown colour, which remained by the side of the anal end. The hyperparasitic grub does not spin a cocoon within which to pupate, but its pupa remains free by the side of its hosts but within the cocoon spun by the Dryinid.

Two species of hyperparasites were bred out and cannibalism amongst the grubs was noted distinctly in one species. In the other, no definite observations could be made, as in the first instance, it was not thought that there were two species parasitic on the Dryinid grubs. It was only when two different species had emerged that attempts were made to obtain a fresh lot of parasitized Dryinid (*C. pallidus*) grubs were made ; but these attempts were not successful, It is just possible that cannibalistic tendencies were developed in the hyperparasitic grubs on account of the paucity of space within which they had to exist and to develop themselves. If such be the case, they may be said to be cannibalistic in confinement.

Description of the hyperparasitic grub.

Length 1·77 mm., breadth over the thorax 0·60 mm., breadth of the last abdominal segment 0·27 mm.; body distinctly transversely segmented—segments 14 including the head; apodous; colour light fuscous lilac. (Fig. 9.)

× 15

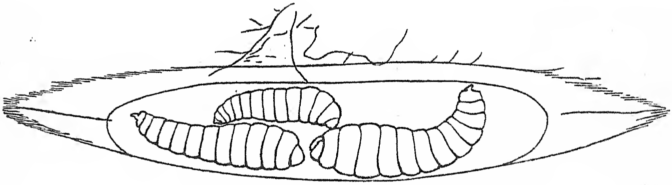


FIG. 9. POSITION OF GRUBS OF A PARASITE PARASITIC ON THE PUPÆ OF *Chlorodryinus pallidus*, PERKINS × 15 (Original) PUSA, 7TH DECEMBER 1914.

The grub exudes a thin slime from its mouth and, when taken out of the cocoon of its host and put on a glass-slide, remains fixed and does not fall off.

Description of the pupa of the hyperparasite.

(*Dorsally, 3rd day after pupation.*)

Length 1·62 mm.; greatest breadth over the abdomen basally 0·63 mm.; breadth of vertex 0·42 mm.; breadth of pronotum 0·45 mm.; colour pure translucent white; head ovoid, nearly as broad as prothorax behind; legs concolorous with the body, tucked up and adpressed to the sides; small, cylindrical, dark castaneous, pellets of excreta remain adhering to the anal end.

The pupa is bare and is not enclosed in a cocoon of any texture whatsoever.

(*Ventrally, 3rd day after pupation.*)

Head pressed to the prosternum; compound eyes represented by the coalescence of eight small, circular translucent orbs; antennæ thick, pressed against the head laterally; legs concolorous with the body and hence cannot be easily differentiated; abdominal segments not very distinct.

(*Dorsally, 6th day after pupation—Pupated* 10*th December* 1914. *Described* 15*th December* 1914.)

The pupa has turned dark, shiny black; the front of head representing the space between the eyes anteriorly, a dark fascia running down the centre

of a white line extending from the vertex to the frons, the thorax, abdomen, legs and antennæ dark shiny black; eyes large, orbicular, concolorous with the head. A thin line extending from the front of vertex to the base of scutellum dorso-centrally whitish; pronotum small, transverse; scutellum rhomboidal, its anterior margins white; abdominal segments nine, their basal areas being transversely thinly punctate.

(*Ventrally, 7th day after pupation—Pupated* 10*th December* 1914. *Described* 16*th December* 1914.)

General colour of the pupa dull slaty-grey; two ovoid patches on the vertex, a central fascia on vertex, the scape with the rest of the antennal joints, mandibles, maxillary palpi, labium with palpi, legs and wing pads shiny black; antennæ geniculate, their apex reaching the base of mesosternum; anterior legs by the side of antennæ and reaching base of mesosternum; intermediate legs reaching the fifth abdominal segment laterally; the posterior legs reaching the pre-anal segment laterally; abdominal segments not very distinct, centrally raised forming a thin ridge extending from the base to the anal end.

The pupal period of the hyperparasitic grubs was found to vary from 22 to 25 days during December 1914, and January 1915:—

I.	10th December 1914	..	.. Grub pupated.
	3rd January 1915	..	.. Adult emerged, 24 days.
II.	10th December 1914	..	.. Grubs pupated.
	1st and 2nd January 1915	..	.. Adults emerged, 22-23 days.
III.	14th December 1914	..	.. Grubs pupated.
	5th to 8th January 1915	..	.. Adults emerged, 22-25 days.

The Adult Hyperparasite. Length 1·71 mm.; greatest breadth over thorax 0·51 mm., expansion 2·91 mm., greatest width of forewings 0·39 mm.; antennæ 11 joints, rather stout; flagellum finely hairy, scape as long as 2nd, 3rd, 4th and 5th joints together; joints 8, 9 and 10 thickened together forming the club, dark greyish-brown; flagellum, head, thorax and abdomen pale dark-fuscous; legs pale stramineous; eyes concolorous with the head; tibial spur to hind tibiæ nearly as long as the first and the second tarsal joints; marginal vein to forewing translucent pale white; a thick dark patch made up by coalescence of small, dark hairs at the junction of the sub-marginal vein with the marginal vein; a broad dark-grey patch in the middle of the forewing starting a little beyond centre and extending as far as the outer margin leaving only a clear space of about 0·15 mm. from it. (Fig. 10.)

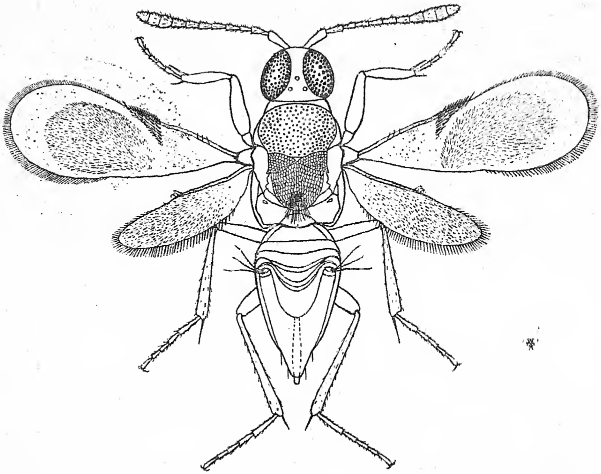


FIG. 10. PARASITE ON *Chlorodryinus pallidus*, PERKINS (+40)
(the small figure shows the natural size).

(The above description is from a specimen stupefied with chloroform, treated with a saturated solution of Phenol in Xylol and mounted in Xylol Balsam.)

(3) STYLOPIDÆ.—*Pyrilloxenos compactus*, PIERCE.

When the sugarcane leaf-hopper, *P. aberrans*, was bad on cane, numerous nymphs and adults of the leaf-hopper were found affected with this stylopid parasite. In the case of nymphs the number of male and female Stylops varied from 1-7 whilst in the case of the adults, the number of Stylops was from 1-12. In no case were more than 12 Stylops seen on the adults from 1907-1915 when the cane leaf-hopper was under observation. The nymphs as well as the adults do not seem to mind much the appearance of the parasites, and in the case of the nymphs it was very queer to see them sidling backwards and forwards on the leaves as well as jumping off from plant to plant with 5 to 7 male and female Stylops on their body. The adult hoppers seemed to be affected much by the presence and subsequent emergence of the male

EXPLANATION OF PLATE XVIII.

Pyrilloxenos compactus, Pierce.

[All the figures drawn on this plate are from specimens treated with KOH and mounted in Xylol × Balsam.]

Fig. 1. Adult *Pyrilla aberrans*, ♀ ventral view showing position of triungulinids and cephalothorax of ♀ *P. compactus* .. .. much magnified.

Fig. 2. Triungulinid of *P. compactus*, ventral vew .. much magnified.

Fig. 3. Triungulinid of *P. compactus*, lateral view .. much magnified.

Fig. 4. *P. compactus* ♀ showing dispersal of the triungulinids from the female into the body of the host .. much magnified.

Fig. 5. *P. compactus* ♀ showing its position in the body of the host laterally .. .. much enlarged.

Fig. 6. *P. compactus* ♀ Cephalothorax ventrally .. much enlarged.

Fig. 7. Triungulinids within the abdomen (ventrally) of *Pyrilla aberrans* (From a specimen boiled hard in KOH and mounted in Xylol × Balsam) .. × 18

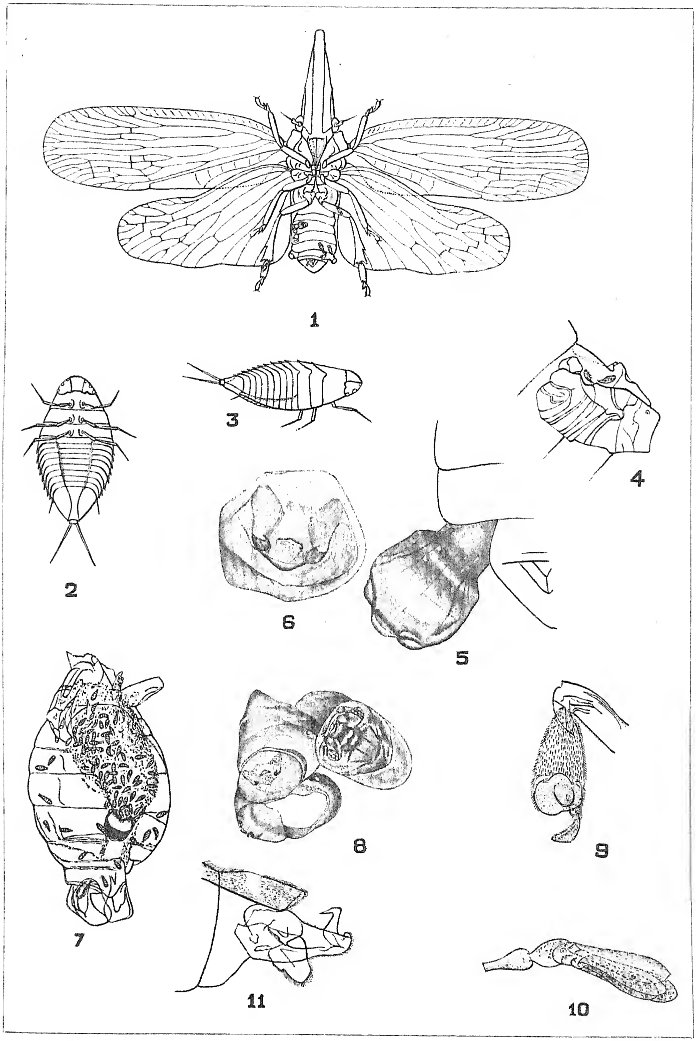
Fig. 8. Cephalothorax showing emergence of ♂ *P. compactus* much enlarged.

Fig. 9. Tarsal joints of ♂ *P. compactus*, lateral view .. much enlarged. (From a specimen boiled hard in KOH and mounted in Xylol × Balsam).

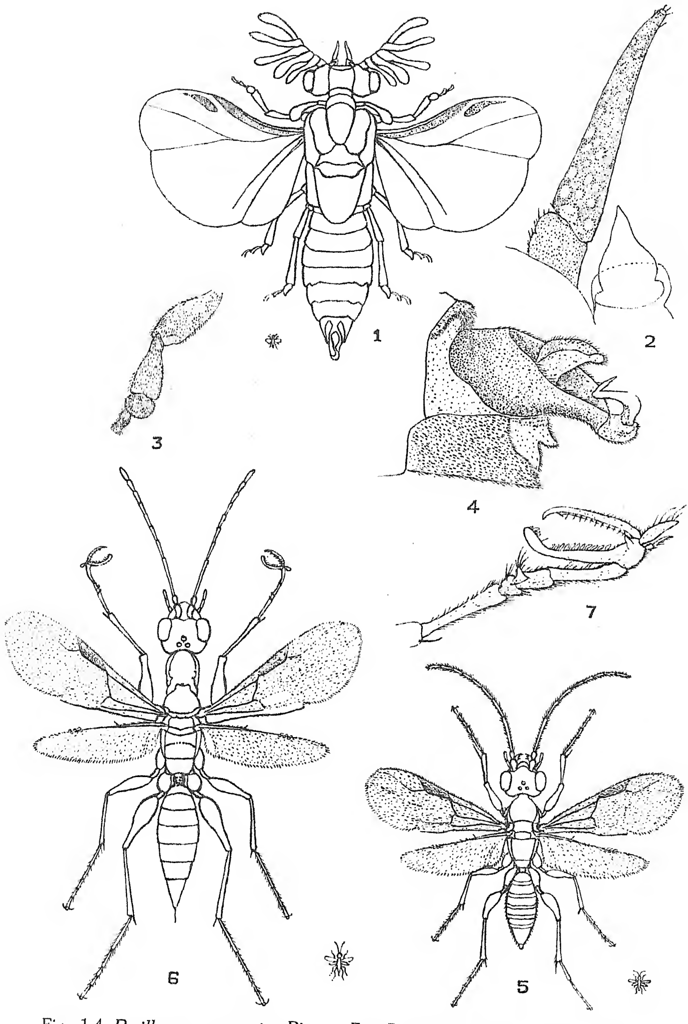
Fig. 10. Antenna of ♂ *P. compactus* .. .. .. much enlarged.

Fig. 11. Male genitalia showing œdeagus laterally .. much enlarged.

PYRILLOXENOS COMPACTUS.



PYRILLOXENOS COMPACTUS.



Figs. 1-4. *Pyrilloxenos compactus,* Pierce; Figs. 5-7. *Chlorodryinus pallidus* Perkins.

Stylops which on coming out of the blackish cylindrical protuberances—the cephalothoraces—projecting out of the abdomen of the hopper, seemed to lacerate the tissues to an abnormal extent, thereby causing death of the host. By the presence of the female Stylops, the hopper was able to jump about and only became sluggish when the triungulids permeated the whole of its body internally. This species was mostly present during 1906, 1907, 1910, 1912, 1914 and 1915, though a few specimens were found during 1913 also. I could not obtain any specimens of this species during 1911 when the leaf-hopper was present on the varietal canes in small numbers. This species infests the leaf-hopper along with the grubs of the Dryinid parasite, *Chlorodryinus pallidus* and *Dryinus pyrillæ*. The male and female Stylops are mostly present on the nymphs and adults of the leaf-hopper on the abdomen ventrally. Only in one solitary instance was a male Stylops seen on the abdomen of *P. aberrans* dorsally. In some cases the abdomen ventrally of adult female leaf-hoppers was so profusely pitted with elongate cylindrical, shiny black male and female Stylops that it was wondrous to see them alive and hopping about. No doubt the presence of the male Stylops seemed to innervate the adult hoppers, as by their emergence the puparium-caps or cephalotheca were clean knocked off and the adult hoppers were found to succumb within two hours of the emergence of the male Stylops.

Pyrilloxenos compactus parasitizes largely whichever species of leaf-hopper happens to be abundant during the year. During 1907, female *P. aberrans* were mostly found affected. This was also the case during 1914 in the beginning of the hopper season, but later on when *P. pusana* increased the Stylops were found to parasitize the male hoppers mostly. On the 7th November 1914, 15 stylopised adult leaf-hoppers were taken in the cane fields. These contained 75 adult Stylops, 48 males and 27 females. Of the 15 leaf-hoppers, 11 were *P. aberrans* (10 females + 1 male), the remaining four were all *P. pusana* male and all were stylopised as will be evident from the following statement :—

Pyrilloxenos compactus, Pierce. 7th November 1914.

No	Species stylopised	Male or female	No. of Stylops	Region of abdomen affected
1	*P. aberrans* ..	♀	6 ♂, 1 ♀ } 7	6 ♂ Pleural region. 1 ♀ Sternal ,,
2	,, ..	♀	3 ♂, 1 ♀ } 4	3 ♂ Pleural ,, 1 ♀ Sternal ,,
3	,, ..	♀	1 ♂, 2 ♀ } 3	1 ♂ Sternal ,, 2 ♀ Pleural ,,
4	*P. pusana* ..	♂	3 ♂, 1 ♀ } 4	2 ♂ Pleural ,, 1 ♂ Sternal ,, 1 ♀ ,, ,,
5	*P. aberrans*. ..	♀	2 ♂, 2 ♀ } 4	1 ♂ 1 ♀ Pleural ,, 1 ♂ 1 ♀ Sternal ,,
6	,, ..	♀	2 ♂, 4 ♀ } 6	2 ♂ Pleural ,, 4 ♀ Sternal ,,
7	,, ..	♀	2 ♂, 1 ♀ } 3	2 ♂ Pleural ,, 1 ♀ Sternal ,,
8	*P. pusana* ..	♂	3 ♂, 3 ♀ } 6	3 ♂ Pleural ,, (right). 3 ♀ ,, ,, (left).
9	*P. aberrans* ..	♀	1 ♂	1 ♂ Sternal region. (Base of anal segment.)
10	,,	♂	3 ♂	3 ♂ Pleural region.
11	*P. pusana* ..	♂	4 ♂, 1 ♀ } 5	2 ♂ Pleural region. 1 ♂ Sternal region. 1 ♂ ,, ,, (Base of anal segment.) 1 ♀ Pleural region.
12	*P. aberrans* ..	♀	1 ♂, 4 ♀ } 5	1 ♂ Pleural region. 4 ♀ ,, ,,
13	,, ..	♀	7 ♂, 3 ♀ } 10	7 ♂ Pleural ,, 3 ♀ ,, ,,
14	,, ..	♀	7 ♂, 3 ♀ } 10	7 ♂ Pleural ,, 3 ♀ ,, ,,
15	*P. pusana* ..	♂	3 ♂, 1 ♀ } 4	3 ♂ Pleural ,, 1 ♀ ,, ,,

8th, 9th and 10th specimens free from Stylops.

On the 15th November 1914, another lot of 10 specimens were taken in the fields and these contained the Stylops thus :—

No.	Species stylopised	Male or female	No. of Stylops	Region of abdomen affected.
1	*P. pusana* ...	♂	3 ♂, 2 ♀ } 5	3 ♂ Pleural region. 2 ♀ " "
2	*P. aberrans* ...	♀	5 ♂, 6 ♀ } 11	5 ♂ Pleural " 6 ♀ " "
3	" ...	♀	1 ♂, 4 ♀ } 5	1 ♂ Pleural " 3 ♀ " " 1 ♀ Sternal "
4	*P. pusana* ..	♀	6 ♂, 4 ♀ } 10	6 ♂ Pleural " 4 ♀ " "
5	*P. aberrans* ...	♀	3 ♂, 3 ♀ } 6	3 ♂ Pleural " 3 ♀ " " (right).
6	*P. pusana* ...	♂	5 ♂, 3 ♀ } 8	3 ♂ Pleural " (left). 1 ♂ Sternal " 1 ♂ Dorsal side. 3 ♀ Pleural region.
7	" ..	♀	6 ♂, 4 ♀ } 10	6 ♂ Pleural " 4 ♀ " "

8th, 9th and 10th specimens free from Stylops.

The parasitization of the cane leaf-hoppers, *P. aberrans* and *P. pusana*, by the Stylops, though noticed for the first time at Pusa in August 1907, was present as early as 1900 (*Indian Museum Notes*, Vol. V, No. 2, p. 43, 1900), when the cane leaf-hopper, *P. perpusilla*, was for the first time reported as damaging sugarcane in South Arcot in the Madras Presidency. This fact was noticed when specimens of the leaf-hopper were received from the Indian Museum, Calcutta, for comparison with the specimens of leaf-hoppers bred out at Pusa. The specimens from South Arcot, though labelled as *Dictyophara pallida*, Don., in Mr. Atkinson's own handwriting, were *Pyrilla perpusilla*, Walk., and in these the female Stylops were situated on the abdomen ventrally.

Hitherto only one species of Stylops was recorded from India (*Genera Insectorum*, Fasc. 121, 1911, p. 6). The specimens from *P. aberrans* and

P. pusana were sent to Mr. W. Dwight Pierce, Bureau of Entomology, U. S. Department of Agriculture, who, while erecting a new genus *Pyrilloxenos* under subfamily *Halictophaginæ*, and a new species *compactus* to receive the specimens bred out from the Indian Sugarcane Leaf-hoppers, wrote :—

"I am now able to describe two additional species of Halictophaginæ important as enemies of sugarcane leaf-hoppers from the two Hemispheres. One was obtained in very large numbres by Mr. Thomas H. Jones of Porto Rico at Rio Piedras, as a parasite of the destructive *Stenocranus saccharivorus*, the other was found by Mr. C. S. Misra, at Pusa, India, as a parasite of the sugarcane fly of India, *Pyrilla* sp.*

"The genus *Stenocranus* belongs to the Fulgorid family Delphacidæ, and the genus *Pyrilla* belongs to Fulgorid family Lophopidæ.†

"FAMILY HALICTOPHAGIDÆ.

Subfamily Halictophaginæ.

"*Male.* Head not conspicuously excavated behind. Eyes large, convex with very large facets. Mandibles short, triangular, glabrous. Antennæ short, seven jointed, flattened foliaceous, with large sensory pits ; first two joints simple, the second shorter ; the remaining five joints crowded, each broadened in a broad lamina, the apices of which are about even with each other, the entire antennæ not longer than width of head.

"Pronotum very short, transverse bandlike. Mesonotum a little longer, also bandlike. Elytra pedunculate spatulate, sensitive, pubescent. Metanotum with præscutum rounded, keystone-shape, truncate, sinuate at apex, longer than scutellum and postlumbium together ; scuti oblique considerably surpassing præscutum at outer angles and supporting it by a tiny projection at inner angles ; scutellum broad, irregular in outline, narrower at base than præscutum, broadening in a concave line behind scuti, with anterior angles rounded, almost rectangular, and posterior angles diagonally produced as quadrate peduncles, apex otherwise truncate ; postlumbium short, transverse, fitting in between and scarcely surpassing the posterior peduncles of the scutellum ; postscutellum large, convex, broadly rounded.

"Tarsi three-jointed, the first mucronate ; claws absent. Eighth ventral segment acutely produced beneath ninth. Anal segment small, flaplike Œdeagus strongly bent, broad near base, rectangularly bent near apex, apical process slender and very acute.

* This has since been identified as *Pyrilla aberrans*, Kirby.

† *Proceedings, Entomological Society, Washington*, vol. XVI, no. 3, 1914, pp. 126, 128 and 129

"The generic name is derived from *Pyrilla* (the host genus) and *Xenos* (the typical Strepsipterous genus) signifying a Strepsipterous parasite of *Pyrilla*.

"Type of genus—*COMPACTUS* n. sp.

"PYRILLOXENOS COMPACTUS *Pierce*.

"Described from a type female, and allotype male, and two paratype females from Pusa, Bihar, India, collected by C. S. Misra.

"The material was collected in August 1907, March 15th, 1913, and May 23rd, 1914. The specimens collected in August 1907, consist of allotype male, male pupa cephaletheca, and three paratype females with triungulinids. This material is the property of the Entomological Section, Agricultural Research Institute, Pusa. The type is deposited in the United States National Museum, and a paratype female is in the author's collection. The author is indebted to Mr. T. Bainbrigge Fletcher, Imperial Entomologist, for the material. The specific name is intended to draw attention to the compact appearance of the antennæ.

"*Male.* Length 1·5 mm. The tarsi are very small. The anterior tibiæ are very robust and shorter than on the other legs. The antennæ are much more compact than is usual in this family. The mandibles cannot meet. The remainder of the description is to be drawn from the generic description. The specimen was unfortunately boiled in caustic potash and is therefore very hard to study.

"*Female.* Cephalothorax golden yellow to brownish, broader than long; constricted behind spiracles; sides quite evenly rounded; apex sinuate. Mandibles obtuse, separated by almost three times their width. Front convex. Spiracles just touching margin.

"Type in U. S. Nat. Mus.—Cat. No. 18814."

TREATMENT.

During 1906, when the cane leaf-hopper attacked the varieties of canes at Pusa in large numbers, the measures adopted to check it from seriously damaging the canes were :—

(1) Collection of eggmasses and rearing the parasites and liberating them in the fields.

(2) Spraying the plants with Crude Oil Emulsion and Sanitary Fluid at $\frac{1}{2}$ pint to 4 gallons of water.

The trees in the immediate vicinity of the cane-plots, which were profusely covered with eggs (Plate XI, fig. 1), were also sprayed with Crude Oil Emulsion and Sanitary Fluid.

(3) Bagging the nymphs and imagines on grasses with different types of field-bags.

1. *Collection of eggmasses.* This was mostly done by boys in charge of head coolies during August-December, 1906. The leaves, as they were collected, were put in parasite boxes or earthen pots—locally known as *gumlas*. The mouth of such pots was covered over with cheese-cloth having meshes sufficiently wide to allow the parasites only to emerge but not the nymphs. This was done during 1906, 1907, 1908 and 1910 and was used on a large scale during 1914, when nearly 40-50 pots were put in an area of one acre and a half. In 1914, the work began by the beginning of April and was continued until the third week of November. By the end of November 1914, with the disappearance of eggmasses, the parasites also disappeared and the work was stopped completely. In fact, during 1914 recourse was had only to two measures of dealing with the pest—

(1.) Bagging the adults in April when they appeared on the newly-planted canes as well as in the ratoon crop. This was repeated occasionally as long as it was possible to work the hand-nets and the field-bags in the fields.

(2.) Collection of parasitized eggmasses, putting them in parasite boxes and liberating the parasites in the fields. The work lasted from April to the third week of November, and was found to be very efficacious in checking the pest to a very large extent. The work is very simple, is easily done by boys who being once shown the eggmasses readily recognize them and collect them in the fields, and is neither very costly nor tedious.

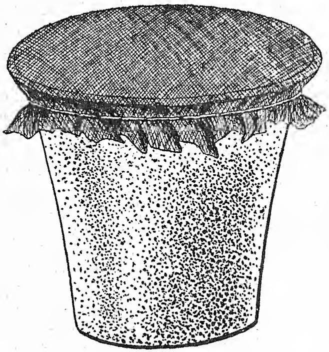


FIG. 11. AN EARTHERN POT (*gumla*) COVERED WITH CHEESE-CLOTH USED AS A PARASITE-BREEDING CAGE.

With these two measures the pest was kept under check and no spraying or bagging had to be done.

2. *Spraying the eggmasses, nymphs and adults with Crude Oil Emulsion and Sanitary Fluid at ½ pint to 4 gallons of water.* During 1906 and 1907, when enormous numbers of the cane leaf-hoppers had laid eggs on bamboos, *Ficus religiosa* and other trees in the immediate vicinity of the cane-plots, these were sprayed with Crude Oil Emulsion to prevent emergence of the nymphs.

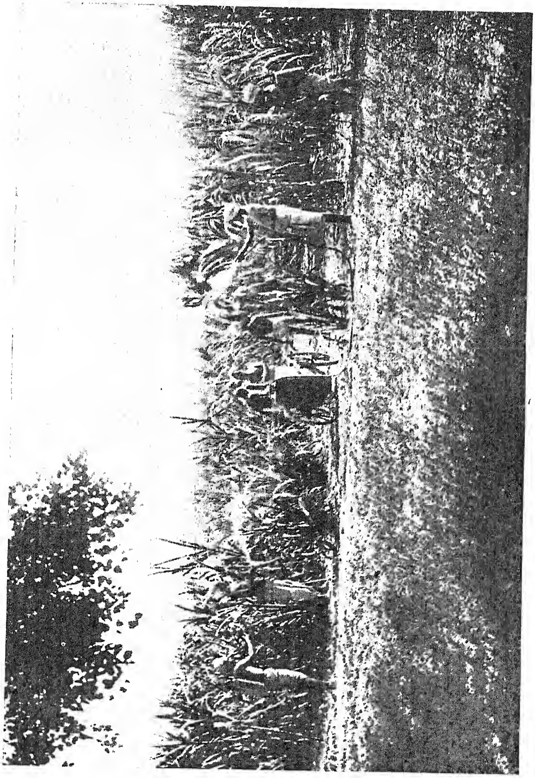
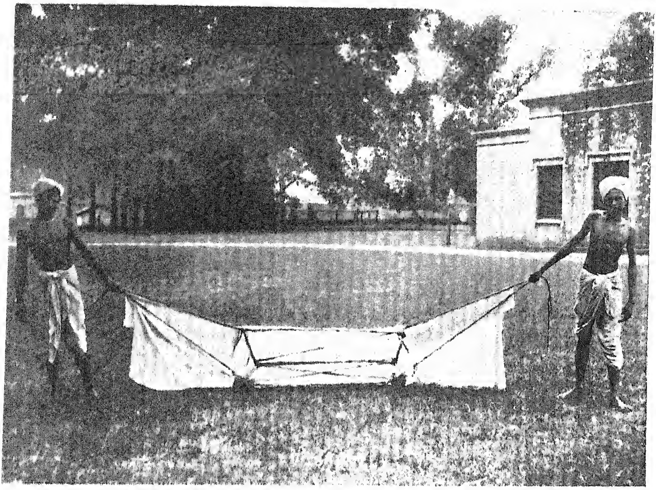


Fig. 12. Spraying machines at work. (Original.)

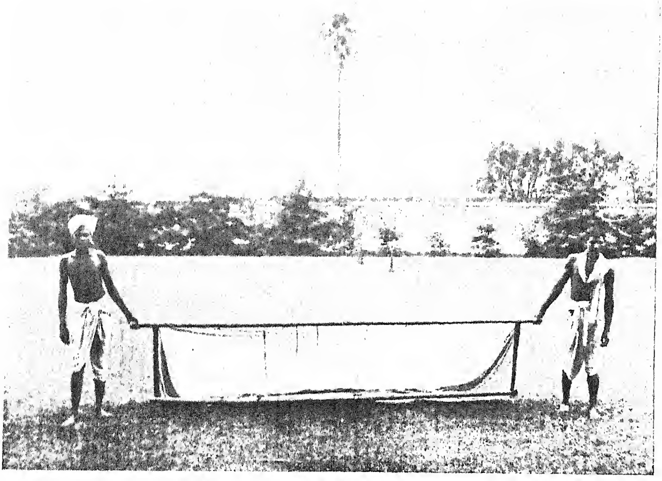
Fig

Fi

XV.



. 13. Field-Bag (Type A) used to bag the cane leaf-hopper in grasses during 1908. (Original.)



g. 14. Field-Bag (Type B) used to bag the cane leaf-hopper in grasses during 1908. (Original.)

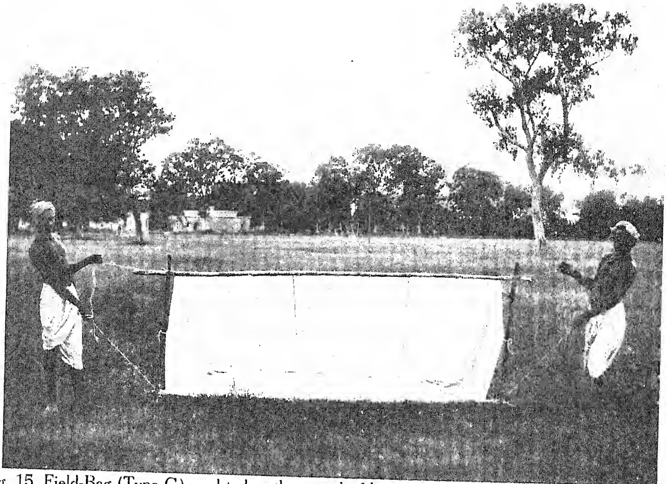


Fig. 15. Field-Bag (Type C) used to bag the cane leaf-hopper in grasses during 1908. (Original.)

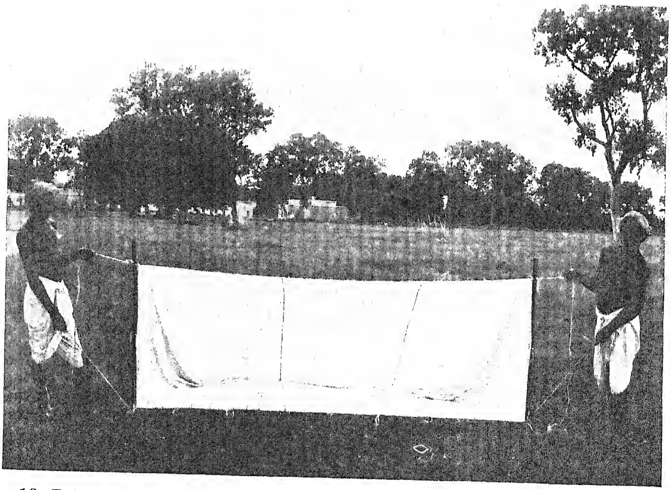


Fig. 16. Field-Bag (Type D) used to bag the cane leaf-hopper in grasses during 1908. (Original.)

A strength of 3 pints Crude Oil Emulsion to 4 gallons of water was found effective, the lighter strengths failed to prevent the emergence of the nymphs :—

Strength of Crude Oil Emulsion	Percentage of eggs hatched out
½ pint to 4 gallons of water	78-88
1 do. do.	48-58
2 do. do.	27-31
2½ do. do.	11-19
3 do. do.	4-7

Side by side with the spraying for the eggs, the varieties of canes were sprayed with Crude Oil Emulsion and Sanitary Fluid at ½ pint and 1 pint to 4 gallons of water. The spraying was done with Gould's Standard Spray Pump mounted on a barrel on a cart and Deming's "Success" Knapsack Sprayers. The former (Plate XIII) is a very powerful machine and works well, provided the cane is not lodged and there is sufficient space between the lines for the barrels to go in. Though five men are required to work it, yet the area covered by it is more than four times the area done by a Knapsack Sprayer which requires only two men to work it. The spraying is best done from 8 A.M. to 4 P.M. when the nymphs as well as the imagines are most active. The first spraying given in November was not so effective and a second spraying had to be given subsequently. With spraying, though the number of nymphs and imagines was considerably reduced, the leaves of certain varieties of canes were more or less affected (*see* Appendix A). A spraying gang consisting of 8 coolies in charge of a head coolie was able to spray 1·25 acres of thickly growing canes on ridges on a working day of 9 hours. The quantity of insecticide used was 27½ pints, and this is a large quantity for the area treated. But this was due to the fact that the furrows which were thickly filled with trash had also to be treated along with the plants on ridges. The average cost of treating an acre was Rs. 10-2.

Cost of treating 4½ acres of sugarcane against the cane leaf-hopper.

	Rs.	A.	P.	Rs.	A.	P.
Collection of healthy and parasitized eggs				3	7	0
Spraying twice with Crude Oil Emulsion and Sanitary Fluid. First spraying at ½ pint to 4 gallons of water. Second spraying at 1 pint to 4 gallons of water.						
Cost of Insecticide	30	6	6			
Labour	7	2	6			
				37	9	0
Spraying the neighbouring trees with Crude Oil Emulsion.						
Cost of Insecticide	2	8	0			
Labour	1	2	0			
				3	10	0
Bagging the nymphs and imagines in grasses, etc.				0	15	0
TOTAL ..				45	9	0
Average per acre ..				10	2	0

3. During 1906 and 1907, the nymphs as well as the adults, when they had scattered themselves in grasses in the neighbourhood of the cane-plots at Pusa, were bagged with different types of field- and hand-bags to prevent them coming back to the canes and laying eggs on the plants. (Plates XIV, XV.)

FIG. 17. HAND-NET (TYPE E) USED TO BAG THE CANE LEAF-HOPPER IN YOUNG CANES, 1907, 1908, 1910 AND 1914 (Original).

The above is a succinct account of what was done during 1906 and 1907. During 1914, the only two measures adopted were (1) the bagging of nymphs and adults with hand-nets (Fig. 17) during March, April and May, and (2) the collection of eggmasses, breeding out the parasites and liberating them in the fields from August to November. These two measures gave satisfactory results and they were not so costly as the measures adopted during the early years.

After having discussed the life-history, the food plants, the parasites and the methods adopted with the leaf-hopper, *Pyrilla aberrans*, in the past, I now proceed to the recommendation of such measures as would be found effective in dealing with the pest, if it breaks out in any locality in large numbers.

I. At the time of planting the cane setts, any eggmasses that are found on the leaves or the trash and the strippings should be collected and put in wide-mouthed earthen vessels locally known as *nands* or *gumlas* or any such receptacle or old deal-wood packing cases, provided the sides are intact and have no holes or crevices to allow the nymphs to escape. The mouths, or the tops of such receptacles, should be tied over with cheese-cloth having meshes sufficiently wide to allow the parasites to emerge but not the nymphs.

II. During March, April and May, if any nymphs and adults are found on the newly-planted as well as the ratoon canes, they should be bagged either with hand-bags, type E (Fig. 17), or field-bag, type D (Plate XV), and destroyed.

III. From August-December as many eggmasses as can be collected should be put in receptacles detailed above. In some years the parasitized eggmasses are found till late in December ; the eggmasses should be collected and put in parasite-boxes as described above. This parasitization is very important and attempts should be made to collect as many eggmasses as possible at this time. By having recourse to this measure fewer nymphs hatch out and the pest, if it develops at all, appears only in small numbers and does not damage the canes to an appreciable extent.

IV. The leaf-hopper has been found to damage the broad-leaved varieties more than the thin-leaved varieties (*see* Appendix B). If in localities where cane is to be grown under irrigation for a series of years, and the leaf-hopper, *Pyrilla aberrans*, as well as its congeners, *P. pusana* and *P. perpusilla*, appear in numbers and affect the cane prejudicially, it would be better to give preference to thin-leaved varieties over thick-leaved ones for a consecutive series of two years at least. If this be not practicable, the measures recommended under I-III above may be adopted.

APPENDIX A.

Effect of spraying varieties of sugarcane with Crude Oil Emulsion and Sanitary Fluid.

No.	Name of variety	1st Spraying	2nd Spraying	Remarks
1	Khari, thin ...	Crude Oil Emulsion at ½ pint=4 gallons of water.	Crude Oil Emulsion at 1 pint=4 gallons of water.	Much affected. Leaves became pale yellow.
2	Kajli, thin black ...	,,	,,	Slightly affected.
3	Samsara, thick ...	,,	,,	Much affected. Leaves became pale yellow.
	Purple coloured, thick without bloom ...	,,	,,	Very slightly affected.
5	White Sanna, thick ...	,,	,,	,,
6	Wine coloured, thick..	,,	,,	,,
7	Numali	,,	,,	,,
8	Red Mauritius ...	,,	,,	The least affected.
9	White Mauritius ...	,,	,,	Slightly affected.
10	Red Paunda ...	,,	,,	,,
11	Dhaulu, thin ...	,,	,,	Not affected.
12	Kuswar	Sanitary fluid ½ pint=4 gallons of water.	Sanitary fluid 1 pint=4 gallons of water.	,,
13	Aghol	,,	,,	,,
14	Hemja	,,	,,	,,
15	Azamgarh, thin, small	,,	,,	,,
16	,, ,, large ...	,,	,,	Very slightly affected.
17	Mungo, thin ...	,,	,,	,,
18	Wansi, thin ..	,,	,,	,,
19	Bonta, white ...	,,	,,	,,
20	Sunnabille ...	,,	,,	,,
21	Bitta Kubba ...	,,	,,	,,
22	Purple coloured ..	,,	,,	Slightly affected.
23	Paunda	,,	,,	Much affected.
24	Numali	,,	,,	Very slightly affected.
25	Red Mauritius ...	,,	,,	Not affected.
26	Burli	,,	,,	,,

APPENDIX B.

Relative immunity of varieties of sugarcane from the attack of the cane leaf-hopper, Pyrilla aberrans.

No.	Name of variety	Presence of the leaf-hopper	REMARKS
1	Khari, thin ...	Hopper present in large numbers.	The first six varieties were very seriously affected and thus formed the basis of comparison. Careful and continuous observations regarding the presence of the leaf-hoppers showed that the broad-leaved varieties were more liable to attack than the thin, short-leaved varieties of cane such as Aghol, Kuswar, etc.
2	Kajli, thin black ...	do.	
3	Samsara, thick	do.	
4	Purple coloured, thick without bloom.	do.	
5	White Sanna, thick ...	do.	
6	Wine coloured, thick	do.	
7	Numali ...	do.	
8	Red Mauritius ...	do.	
9	White Mauritius ...	do.	
10	Red Paunda ...	do.	
11	Dhaulu, thin ...	Hoppers very few.	
12	Kuswar ...	do.	
13	Aghol ...	do.	
14	Hemja ..	do.	
15	Azamgarh, thin, small	do.	
16	,, ,, large	do.	
17	Mungo, thin ...	do.	
18	Wansi, thin ...	Few.	
19	Bonta, white ...	Few.	
20	Sunnabille ...	Hoppers very few.	
21	Bitta Kubba ...	Hoppers few.	
22	Purple coloured ...	do.	
23	Paunda ...	do.	
24	Numali ...	Hoppers many.	
25	Red Mauritius ...	do.	
26	Burli ...	Hoppers few.	

LITERATURE CONSULTED.

Fulgora pallida, Don. 1800. Donovan. Nat. Hist. Ins. India, Edition I, Plate VIII, fig 2.

Pseudophana pallida, Westw. 1838. Westwood in Donovan's Nat. Hist. Ins. India, Edition 2, Plate VIII, fig. 2.

Pseudophana pallida, Westw. 1841. Trans. Linn. Soc. London, XVIII, p. 150, n. 3.

Dictyophara pallida, Don. 1851. Walker, List Hom. Ins. B. M., Part II, p. 310. n. 18.

Dictyophara pallida, Don. 1886. Atkinson, Jour. A. S. B., Vol. IV, Part II, p. 27.

Dictyophara pallida, nec. Don. 1900. A. Alcock. Ind. Mus. Notes, Vol. V, pp. 43-44, 79, 86-87.

Dictyophara pallida, nec. Don. 1903. 164-166, Plate V, figs. 1-6.

Microchoria aberrans, Kirby. 1891. W. F. Kirby. Journ. Linn. Soc. Zool. XXIV, London, p. 147, Plate V, fig. 10.

Microchoria aberrans, Kirby. 1903. Melichar. Homop. Faun. Ceylon, p. 63, pl. 2, fig. 13*a*.

Dictyophara pallida, nec. Don. 1906. G. W. Kirkaldy. Bull. No. 1, pt. 9 Divn. Entom. The Hawaiian Sugar Planters' Association, p. 279.

Dictyophara pallida, nec. Don. 1906. H. M. Lefroy. Ind. Ins. Pests, pp. 133-135.

Zamila aberrans, Kirby. 1906. W. L. Distant. Faun. Brit. India, Vol. III, pp. 326-327, fig. 161.

Dictyophara pallida, nec. Don. 1907. H. M. Lefroy. Mem. Dept. Agri. India. Entom. Series, Vol. I, No. 2, p. 240, fig. 80.

Dictyophara pallida, nec. Don. 1907. W. L. Distant. Annals Soc. Ent. Belgique, Vol. LI, pp. 220-221.

Pyrilla aberrans, Kirby. 1907. G. W. Kirkaldy. Soc. Ent. Belgique, Vol. LI, pp. 123-124.

Pyrilla (Zamila) *aberrans*, Kirby. 1909. H. M. Lefroy. Ind. Ins. Life, pp. 171, 723, 727, fig. 497.

Pyrilla aberrans, Kirby. 1916. T. Bainbrigge Fletcher. One hundred notes on Indian Insects. Bulletin No. 59. Agricultural Research Institute, Pusa. Note No. 97.

Pyrilla aberrans, Kirby. 1916. W. L. Distant. Fauna. India Rhynchota, Vol. VI, (Homoptera appendix), p. 85.

PREFACE.

THE following paper contains a systematic description of a collection of Indian Termites, made principally by myself in 1911-12 and sent out for identification in 1913. The original manuscript was written in German and has been translated into English by me. In forwarding it, Professor Nils Holmgren writes:—"The manuscript has been ready about two years and I have made many efforts to get it published here, but in vain. The few Swedish journals have been overwhelmed with manuscripts, as an effect of the disastrous war, and it has been impossible to get it published in Germany or elsewhere."

A further collection, made by me during a tour in Southern India in 1914 and containing several novelties, was also sent to Professor Holmgren in July of that year, but the parcel never reached its destination and was probably lost in one of the mail-steamers which were sunk in the North Sea shortly after the outbreak of the war.

In the present paper a considerable number of forms are described as new and their description will make it possible to write up further notes on their habits and occurrence. The notes in the present paper, enclosed within inverted commas, are the original notes sent with the specimens to Professor Holmgren, to whom we are much indebted for his care and trouble in identifying and describing this collection.

All the specimens referred to were collected by me unless otherwise stated.

T. BAINBRIGGE FLETCHER,
Imperial Entomologist.

PUSA,
21st December, 1916.

REPORT ON A COLLECTION OF TERMITES FROM INDIA

BY

KARIN AND NILS HOLMGREN, STOCKHOLM.

INTRODUCTORY.

We have received the undermentioned collection from the Imperial Entomologist, T. Bainbrigge Fletcher, of Pusa, Bihar, India. It is a collection of great importance, in that it has been made in the most diverse parts of India. Furthermore, it is the largest which has hitherto been made in India. As is to be expected, it contains a large number of new and interesting forms. The material is very rich in forms of *Odontotermes*, especially of the *obesus* group. The most recent material leads us to suppose that a considerable number of local forms of *O. obesus* occur in India. This supposition appears to be verified by the fact that Fletcher has informed us that the structure of the nest is very variable in different localities. But since the soldiers and workers are very little differentiated and the more differentiated imagines belonging thereto are mostly wanting, any local races cannot properly be separated from one another. When imagines are wanting, we have therefore mentioned them only as *O. obesus*.

Of the greatest interest is the new subfamily of Mesotermitidæ, *Stylotermitinæ*, which occupies a position intermediate between the *Leucotermitinæ* and *Protermitidæ*.

Here must also be mentioned the discovery in India of the subgenera *Eutermes* and *Grallatotermes*, of which the latter had only hitherto been found in New Guinea.

REPORT ON THE COLLECTION.

Family PROTERMITIDÆ, Holmgr.

Subfamily HODOTERMITINÆ, Holmgr.

Genus *Hodotermes*, Hagen.

Hodotermes (*Anacanthotermes*) *koenigi*, n. sp.

Imago. Very close to *H. macrocephalus*, but is much larger, with larger head, broader pronotum, 29-30-jointed antennæ, and of generally darker colour. The posterior branches of the radius sector are numerous as in *H. macrocephalus* and the median does not nearly reach the apex of the wing.

Length with wings	...	...	30·00 mm.
„ without „	...	...	14·00 mm.
Breadth of head	...	...	3·42 mm.
„ „ pronotum	...	...	2·85 mm.
Length „ „	...	...	1·71 mm.

Soldier. Much larger and more robust than in *H. macrocephalus*, with longer jaws and darker in colour. Transverse sutures posteriorly arcuate and meeting, not forming an angle. Antennæ with 30 joints. Frons distinctly impressed in centre. Pronotum broad, trapeziform, with rounded edges and straight posterior margin (in *macrocephalus* almost semi-circular with convex posterior margin).

Length of body[1]	...	...	14-15·00 mm.
Head with jaws	...	...	8·00 mm.
„ without jaws	...	...	5·20 mm.
Breadth of head	...	...	4·65 mm.
„ „ pronotum	...	...	3·60 mm.

Worker-like forms. The largest of these have 32-jointed antennæ and a head-breadth of 4 mm.

Locality. South India, Coimbatore. 11th May 1912. Extracted from tunnels in the ground.

Remarks. Whether *H. viarum* is identical with this species cannot be demonstrated. In any case *H. viarum* is only a name which cannot be

[1] The variation in size is large as in all species of *Hodotermes*.

applied to any particular species. *H. viarum* is a "species negligenda" of the first rank.

Hodotermes (Anacanthotermes) macrocephalus, Desn.

The collection contains a few *Hodotermes* workers which apparently belong to this species.

Locality. Sind. "Mile 120 on railway from Badin to Hyderabad." 21st January 1911.

Subfamily CALOTERMITINÆ, Holmgr.

Genus *Calotermes*, Hagen.

Calotermes (Neotermes) fletcheri, n. sp.

Imago. The imago is very close to that of *C. greeni* and of *C. assmuthi* and scarcely distinguishable from these. The antennæ are 17-jointed, the third joint shorter than the second. Pronotum as broad as the head.

Length with wings	...	... 14·00-15·00 mm.
" without "	...	... 8·00- 9·00 mm.
Breadth of head	...	... 1·48- 1·79 mm.
" " pronotum	...	... 1·40- 1·79 mm.
Length " "	...	... 0·76- 0·91 mm.

Soldier. Very close to that of *Calotermes greeni* but distinctly smaller, Antennæ 15-jointed, the third joint as long as second, the fourth rather shorter than third. Pronotum much narrower than the head.

Length of body ...	...	...	9·00 mm.
Head with jaws ...	...	...	4·67 mm
" without " ...	...	...	3·15 mm.
Breadth of head ...	...	...	2·47 mm.
" " pronotum	...	...	2·09 mm.
Length " "	...	...	1·06 mm.

"Workers," 8 millimetres long, are also present in the collection.

Locality. South India, Coimbatore.

Calotermes (Glyptotermes) coorgensis, n. sp.

Imago. Unknown.

Soldier. Two scarcely distinct sizes. Head yellowish-red, anteriorly brown. Jaws blackish brown. Antennæ, labrum, and remainder of the body yellowish. Hairs very sparse.

Head quadrangular, approximately twice as long as broad, cylindrical. Frons sloping, medially depressed above, consequently bilobed with rounded

lobes. Post-clypeus short. Labrum rounded, reaching to one-half of the closed jaws. Jaws longer and more slender than in *Calotermes brevicaudatus*. Dentition : *see* figure below.

Antennæ 10-jointed, third joint very slightly shorter than second, fourth somewhat broader than third. Pronotum trapeziform. Anterior corners somewhat sharp-angled, posterior angles broadly rounded. Anterior margin concave, posterior margin incised.

Length of body ...	...	...	5·9-6·00 mm.
,, ,, head with jaws	...	...	2·05 mm.
,, ,, ,, without ,,	...	...	1·37 mm.
Breadth of head	...	...	1·10 mm.
,, ,, pronotum	...	...	1·06 mm.
Length ,, ,,	...	...	0·49 mm.

Smaller Soldier.

Length of body ...	...	...	4·20 mm.
,, ,, head with jaws	...	...	1·94 mm.
,, ,, ,, without ,,	...	...	1·29 mm.
Breadth of head ...	...	...	0·99 mm.
,, ,, pronotum	...	...	0·95 mm.
Length ,, ,,	...	...	0·46 mm.

Worker-like forms are also present in the collection.

Locality. Coorg, Sidapur, 3,500 feet, 16th November 1912. "Tunnelling in the still solid wood of an old log of red cedar."

Family MESOTERMITIDÆ, Holmgr.

Subfamily LEUCOTERMITINÆ, Holmgr.

Genus *Leucotermes*, Silv.

Leucotermes indicola, Wasm.

Soldiers and workers are present in the collection.

Locality. Punjab, Dhar (Gurdaspur district), 21st August 1911 ; Fateh Mahomed coll.

Subfamily STYLOTERMITINÆ, n. subf.

Imago. Head circular. Fontanelle with fontanelle-gland. Post-clypeus very short. Mandibles with dentition of *Leucotermes* type, in which the apical tooth is large, much larger than the second, and the third tooth much smaller than second.

Anterior wing-stumps large. Radius-sector joined with the costal margin by numerous vertical standing unions. Wing-membrane strongly reticulated with accessory veins arising vertically from the nervures. Median approximated to the cubitus, single. Styli appear to be wanting. Tibia with three apical spines.

Soldier. Large, of *Calotermes* type. Jaws coarse, very robust. Left mandible with two anterior rudimentary teeth and a larger posterior tooth before the basal tooth. Right mandible with two indistinct rudimentary teeth before the basal tooth. Labrum rounded, paler than the head, without hyaline tip, of *Calotermes* type. Antennal joints decreasing in size towards apex, third longer than second, inverted cone-shaped, dark-coloured.

Pronotum semi-circular, concave anteriorly. Lower half of the lateral margin of the metanotum with a posteriorly-directed, slender, short projection. Styli absent. Tibia with three apical spines.

Worker. Head circular, with fontanelle and fontanelle-plate. Post-clypeus as in imago. Left mandible with larger apical tooth than in the imago. Third tooth almost rudimentary. Meso- and meta-notum with well-developed pleural (sub-coxal) projections, of which that of the metanotum is bent posteriorly like the stump of a wing. Styli absent. Tibia with three apical spines.

Genus *Stylotermes*, n. gen.

Imago. Relatively small, dark-coloured.

Head circular. Fontanelle with fontanelle-opening and gland present. *Post-clypeus very short.* Labrum cup-shaped, short. *First tooth of mandible longer than the rest. Third tooth of left mandible much smaller than second.* Dentition almost as in *Leucotermes*. Antennæ 18-jointed.

Anterior wing-stump large. *Radius-sector dark, thickened, joined to the costal margin of the wing by numerous short veinlets.* The whole hyaline wing-membrane strongly reticulated with veinlets *proceeding vertically from the main nervures. The median* of the forewing *free from the stump,* passing nearer to the cubitus than to the radius-sector, single. Cubitus with numerous (as many as 20) relatively short closely placed branches to the posterior margin of the wing. Cerci short. *Styli absent.* Tarsi with three pointed spines.

Soldier. In proportion to the imago very large and stoutly built. It strongly recalls a *Calotermes* (*flavicollis*) soldier, but possesses almost the same peculiarities as in *Leucotermes.* Eye-spots present.

Head rectangular. *Labrum short, semi-circular.* Mandibles *thick, stout,* slightly bent, with dentition characteristic of the mandibles of *Leucotermes* soldiers. Antennæ 15-jointed(?), more slender posteriorly, second joint very short, third long, inversely cone-shaped. Upper part of the femora stout. *Styli wanting.*

Worker. General appearance as in the worker of *Leucotermes.* Mandible with large apical tooth and small third tooth. Antennæ 15-jointed. Eye-spots present. Mesonotum, and especially the metanotum, with *long* slender processes, like wing-stumps, projecting from the lower half of the tergites. *Styli wanting.*

Stylotermes fletcheri, n. sp.

Imago. Dark brown. Post-clypeus, labrum, antennæ, a yellow mark on the pronotum, anterior portion of meso- and meta-notum and legs rust-yellow. Abdominal sternites whitish medially. Submentum slightly darker than the remainder of the underside of head. Wings hyaline with dark costal margin.

Hairs of head projecting, rather sparse, other hairs rather thick. Wing with isolated hairs.

Shape of head (see above). Eyes of medium size, projecting little. Ocelli of medium size, distant from the eye less than their diameter. Post-clypeus not longer in the middle than at the sides. Antennæ 18-jointed (?) second joint as long as fourth, third somewhat longer.

Length with wings	...	...	12·00-12·50 mm.
„ without „	...	...	6·50 mm.
Breadth of head	...	...	1·52 mm.
„ „ pronotum	...	...	1·22 mm.
Length „ „	...	...	1·05 mm.

Soldier. Head brown-yellow, anteriorly slightly darker. Labrum yellow. Pronotum brown-yellow, body straw-yellow.

Head and thorax with a few hairs, abdomen tolerably hairy.

Head rectangular, distinctly longer than broad, rather flattened. Fontanelle distinct, with fontanelle-gland. Labrum almost semi-circular. Mandibles very stout, only once indented at base. Antennæ apparently 14-15-jointed, third joint large, darker than the others, inverse-cone-shaped.

Pronotum almost semi-lunar, anteriorly concave, with rounded anterior angles.

Length of body	...	...	...	8·00 mm.
Head with jaws	...	...	...	4·18 mm.
,, without jaws	...	...	...	2·66 mm.
Breadth of head	...	...	...	1·71 mm.
,, ,, pronotum		...	...	1·44 mm.

Worker. Whitish with pale straw-yellow head.

Head with scattered hairs. Abdominal tergites with two rows of bristles.

Head almost circular. Fontanelle almost in the middle of the head. Condyles of jaws large. Jaws with large apical tooth and almost rudimentary third tooth. Post-clypeus very short. Antennæ short, 15-jointed (?), second joint relatively short, third slightly shorter than second, fourth and fifth equally large somewhat shorter than third, sixth slightly longer than fifth.

Pronotum flattened, narrower than head, more than twice as broad as long, with rounded angles. Pleura of the meso- and meta-notum each with a pair of stumpy, stout, posteriorly-directed processes, those on the mesonotum very short, those on the metanotum almost as long as the femora.

Length of body	...	...	...	6·00 mm.
Breadth ,, head	...	...	...	1·22 mm.
,, ,, pronotum		...	...	0·99 mm.

Nymphs. White. Antennæ 17-jointed. With long wing-sheaths and *below these with small processes* as in the workers.

Larvæ. Two larvæ, 3 mm. long, are included in the collection. The meso- and meta-thorax with very distinct lateral processes. Those of the mesonotum are conical, those of the metanotum are bent into a knee-shape (jointed) with a stouter basal joint and a slenderer apical joint. Apical joint slightly incurved.

Locality. South India, Shevaroy Hills, about 4,000 feet; 16th October 1912. "Burrowing in rotten interior and in sound wood of a mango-tree."

The Systematic Position of the Stylotermitinæ. A glance at the above descriptions is sufficient to show that *Stylotermes* belongs to the Mesotermitidæ. All the conditions are in complete agreement regarding the Mesotermitid affinities of the Stylotermitinæ.

Although *Stylotermes* must be admitted to be a Mesotermitid, yet it cannot be denied that the genus also shows some connecting links with the Protermitidæ, which are more distinct than in perhaps any other Mesotermitid genus. It is the soldier caste which most clearly throws into bold

relief its correspondence with the Protermitidæ and especially with *Calotermes*. Nowhere amongst other Mesotermitidæ does one find such a *Calotermes*-like labrum as that of *Stylotermes*, nowhere else are the antennæ so *Calotermes*-like, and also with regard to the structure of the mandibles we see in their robust build a likeness with *Calotermes* which is unmistakeable. The dentition is also irregular but the typical *Calotermes* teeth are present in the *Stylotermes* soldier, even if in a rudimentary condition and displaced basewards.

As regards the build of the soldier also *Stylotermes* can be connected directly to *Calotermes*, and exhibits an especially distinct link between the Protermitidæ and the Mesotermitidæ.

The imago, on the other hand, does not show the essential characters of a Protermitid, but exhibits undoubted Mesotermitid peculiarities.

The position of *Stylotermes* is extremely interesting in that this genus occupies, so to speak, a position intermediate between the Leucotermitinæ and Coptotermitinæ (and Rhinotermitinæ). The soldier caste is that of a Leucotermitine, but the imago caste shows a mixture of characters of *Leucotermes*, *Arrhinotermes*, and *Coptotermes*.

The shape of the head of the imago is that of a *Coptotermes*, as are also the shape and length of the post-clypeus. The fontanelle is as in *Leucotermes* in that the fontanelle-gland possesses a distinctly short, slender, chitinous, excretory duct. The arrangement of the alar nervures is essentially as in *Leucotermes*, but the reticulation belongs rather to that of an *Arrhinotermes* than to that of *Leucotermes* (subg. *Reticulotermes*). Peculiar characteristics are the absence of styli and the special armature of the mandibles of the imago.

Our opinion of *Stylotermes* is therefore that this genus occupies a more primitive position in the neighbourhood of the joint line of descent of the Leucotermitinæ and Coptotermitinæ and that it connects the Mesotermitidæ with the Protermitidæ (*Calotermes*).

The meso- and meta-thoracic processes, which are mentioned in the description, are of interest inasmuch as they recall wing-stumps. But they have *nothing* to do with wings since they are pleural outgrowths and are present in the nymphs together with the wing-sheaths. Probably they are analogous to the posteriorly-directed processes which have been mistaken for "wing-stumps" in young larvæ of *Calotermes rugosus* and *Glyptotermes dilatatus*.

Subfamily Coptotermitinæ, Holmgr.

Genus *Coptotermes*, Wasm.

Coptotermes heimi, Wasm.

Imagines, soldiers, and workers are contained in the collection.

Localities :

(1) Punjab, Jullundur. Bhup Narain Singh coll.

(2) Bihar, Pusa. "On wing at dusk by river bank, 8th June 1911."

(3) Bengal, Chaumahani. "Under galleries on bark of *Ficus*, 5th December 1911."

(4) Madras, Bellary District, Kottur. "Under a log."

(5) Madras, Bellary District, Bellahunisi. "From old log lying on the ground."

(6) Madras, Adoni. "Running galleries into stem of mango-tree." Y. Ramachandra Rao coll.

(7) Coorg, Margalli Estate, 3,500 feet. "Attacking wood of old cement-barrel filled with earth and used as a flower-pot."

(8) South Kanara, Vittal; 28th January 1913. "In a dry stem by roadside." Y. Ramachandra Rao coll.

Coptotermes travians, Hav.

Soldiers and workers are contained in the collection.

Locality. Bengal, Noakhali District, Chaumahani; 5th December 1911. "In galleries run over tarred beams in a house" and "under galleries on bark of *Ficus*."

Coptotermes gestroi, Wasm.

Soldiers and workers are present from Dibrugarh, in Assam, collected "in mound and wood on wall," by C. C. Ghosh.

Family METATERMITIDÆ, Holmgr.

Termes-Group, Holmgr.

Genus *Termes*, Linn.

Termes estheræ, Desn.

Imago, soldiers and workers are contained in the collection.

Localities : *

(1) Hadagalli. "From large nest in the ground." Y. Ramachandra Rao coll.

(2) Harpanahalli. "From a nest." Y. Ramachandra Rao coll.

(3) Magala. "15th July, at light after rain."

* All these localities are in the Bellary District, Madras Presidency, but the species also occurs at Coimbatore.—T. B. F.

(4) Hospet. "29th August 1912; nest in ground marked by two small rounded bosses of bare red mud appearing above surface of soil."

Note. Fletcher and, following him, Bugnion also, advance the opinion that this species is identical with the old and hardly more than mentioned *Hodotermes convulsionarius* of König. That it may be so is very probable, but the proof for this is wanting. The description of *H. convulsionarius* is so incomplete as not to allow of any exact determination. Therefore I consider it safest not to trouble about *convulsionarius* and to disregard this "species negligenda" once for all.

[König's description of *Termes convulsionarius* is admittedly insufficient to identify his species from merely morphological characters, but his account of its habits leaves no doubt regarding the species to which his name was intended to apply. On this point, therefore, I am in disagreement with Professor Holmgren, and prefer to sink the name *esthere*, Desn., as a synonym of *convulsionarius*, König.—T. B. F.]

Genus *Odontotermes*, Holmgr.

Subgenus *Cyclotermes*, Holmgr.

Odontotermes (*C.*) *obesus*, Ramb.

Typical imagines are contained in the collection. Soldiers and workers of *obesus* type are also present from various localities, but they are so variable that in the absence of imagines they can only be determined as *O. obesus*, although it is very probable that they often belong to at least distinct races or even species.

Localities and Collectors' Remarks.

South India.

(1) Malabar, Quilandy; 9th September 1912; V. L. Travers-Drapes coll. "Damaging young coconut palms."

(2) Coimbatore; 5th May 1912. "Found in a soft grey comb about fifteen inches below ground-level. Apparently the regular comb-making (? mound-building) species. No sign of a mound above-ground. This was apparently a solitary comb, containing soldiers, workers and young, but no nymphs. Termitophilous Collembola in this comb."

(3) Coimbatore; 12th May 1912. "In old log."

(4) Coimbatore; 13th May 1912. "Under a sheet of mud on tree-trunk."

(5) Coimbatore; 19th May 1912. "Under sheets of mud on tree-trunk."

(6) Coimbatore; 2nd May 1912. "Under clod of earth on edge of *cholam* field on Farm. They had run galleries up from below ground into the clod and were perhaps feeding on dead grass-roots, etc. No mound noticed anywhere near here. The soldiers did not emit any sticky-stuff when handled."

(7) Coimbatore; 6th August 1912. "In galleries on a tree-trunk which they had covered with a sheet of mud. The soldiers bit when disturbed and poured out white secretion from the head."

(8) Coorg, Sidapur, 3,500 feet; 16th November 1912. "From nest of *obesus*-type with small imperforate pinnacles but no openings and little actual mound."

(9) Coorg, Sidapur, Margalli Estate; 18th November 1912. "In mud gallery built over lower side of old log lying on the ground."

(10) Coorg, Margalli Estate; 18th November 1912. "From mound built against trunk of a tree. There was little definite shape about it, but there were a few imperforate pinnacles."

(11) Coorg, Mercara; 21st November 1912. "From small mound on a hill-side. There were only two imperforate peaks, each about six inches high, hollow inside. No real mound. Perhaps a young nest."

(12) Coorg, Mercara; 21st November 1912. "In old half-rotten (but still living) tree filled with mud. The abdomen of soldier is very distended and pure white; it gives out milky sticky-stuff and perhaps the gland for this runs down into the abdomen."

(13) Coorg, on road between Santikoppa and Frazerpett, about four miles from Santikoppa, 23rd November 1912. "Tall mound about five feet six inches high by side of road."

(14) Shevaroy Hills, 4,000 feet; 17th October 1912. "Large mound in red soil; numerous peaks but no openings. Several larvæ of *Orthogonius* in mud-cells with their heads projecting into the large galleries of the termitarium."

(15) Shevaroy Hills, about 4,500 feet; 18th October 1912. "Low mound in black soil, about two to three feet across but only three or four inches high, without peaks or openings."

(16) Bellary; 28th August 1912. "Under a stone. Soldier does not emit sticky-stuff."

(17) Bellary; 28th August 1912. "From ground where cattle-dung had been buried by coprophagous beetles. No mounds hereabouts."

(18) "From old mound on banks of Hagari river between Harpanahalli and Kottur;" 4th September 1912.

(19) "Halfway between Hadagalli and Harpanahalli; 3rd September 1912. Nibbling bark of small tree under cover of a sheet of mud."

(20) "From mound halfway between Hadagalli and Harpanahalli; 3rd September 1912. Termitophilous Blattids and Beetles in the combs."

(21) "From mound on road-side about halfway between Hospet and Bellahunisi; 30th August 1912."

(22) Hospet; 30th August 1912. "Running galleries up wall of bungalow." Y. Ramachandra Rao coll.

(23) Hospet; 7th September 1912. "From large low mound."

(24) "From very large mound on road from Hospet to Kamalapuram; 5th September 1912."

(25) Kamalapuram; 6th September 1912. "Under a stone."

(26) Hagari; 22nd September 1912. "From mound-nest." G. R. Hilson coll.

(27) Mysore city, about 3,300 feet; 14th November 1912. "Covering a *Grevillea* tree under a continuous sheet of red mud beneath cover of which they were eating the bark. Many low nests with *open* chimneys hereabouts."

(28) Bababudin Hills, about 4,000 feet; 2nd November 1912. "From low mound consisting of small truncated cone-shaped peaks without any holes in them. A colony of a *Microtermes* was found in the upper part of one of these peaks."

(29) Bababudin Hills, about 4,100 feet; 3rd November 1912. "In rotten log. Looks like a mound-builder, but no mound seen here."

(30) Bababudin Hills, about 4,500 feet; 4th November 1912. "From mound about two feet high, with many small imperforate pinnacles."

(31) Bababudin Hills, about 4,600 feet; 4th November 1912. "From mound in red soil, about three feet high, with many large pinnacles which were hollow inside and with the interior surface pitted with holes, but no visible exterior openings. Mound-nests not found at a greater elevation than this in these Hills."

(32) Bababudin Hills, about 4,300 feet; 8th November 1912. "In stump of dead *Grevillea*, tunnelling up under dead bark."

(33) Mysore State, Kadur; 31st October 1912. "Under old railway-sleepers."

(34) Mysore State, Chikmaglur, about 3,400 feet; 1st November 1912. "Low mound, about six inches above ground, without openings."

(35) Bangalore; 16th July 1912. "Large pinnacled nest (without open chimneys) around an *Acacia* bush."

(36) Mysore State, Maddur, 18th July 1912. "In *Agave* stump."

(37) Kollegal; 22nd July 1912. "Coming from beneath stone-slab floor of rest-house to attack bottom of wooden box under cover of mud galleries."

Bombay.

(38) Nadiad, 9th August 1911. T. N. Jhaveri coll.

(39) Mile $215^{\underline{10}}$ north of Bombay on B. B. and C. I. Railway; on "Tasmanian railway-sleepers;" 14th February 1911.

Kathiawar.

(40) Mile $49^{\underline{10}}$ on railway between Mehsana and Wadhwan; "in logs beside the line;" 18th February 1911.

Punjab.

(41) Lyallpur; 16th August 1911. "Galleries on tree-trunk."

(42) Gurdaspur; 20th August 1911. "Mound-nest." "In dead wood."

(43) Kasur; 12th August 1911. "From mound eighteen inches high." "Tubular galleries." H. L. Dutt coll.

United Provinces.

(44) Karwapany, Dehra Dun; 14th December 1910; V. S. Iyer coll.

Central Provinces.

(45) Nagpur; 5th September 1911. "In comb underground at roots of tree."

(46) Hoshangabad; 17th September 1911. "From mound-nest No. 103."

(47) Hoshangabad; 19th February 1912. "In old stump filled with mud."

Bengal.

(48) Joth, Malda; 21st March 1911. "From nest." "Under dead wood."

(49) Harra, Bankura; 18th April 1911. "Eating fallen leaves in field." C. C. Ghosh coll.

(50) Harra, Bankura; 18th April 1911. "Eating sugarcane setts." C. C. Ghosh coll.

(51) Bogra; 27th March 1911. "Tall pinnacle-mound."

Odontotermes obesus f. *gurdaspurensis*, n.f.

Imago. Ocelli separated from the eye by almost their diameter.

Length of body with wings...		...	27·00 mm.
Breadth of head...	...	..	2·47-2·66 mm.
,, ,, pronotum	...	...	2·39-2·51 mm.

Soldier. Sides of head rather straighter than in *O. obesus* (large form). Mandibles rather straighter than in the large form [of *O. obesus*]. Antennæ

16-jointed. But it is very variable and cannot properly be separated from *O. obesus.*

Length of body	...	...	... 5·00 mm.
Head with jaws	...	...	... 2·47 mm.
„ without jaws	...	...	... 1·52 mm.
Breadth of head	...	...	... 1·25 mm.
„ „ pronotum		...	... 0·95 mm.

Worker as in *O. obesus.*

Locality. Gurdaspur; 20th August 1911. "Swarming from hole in ground after rain, at 9 A.M. No mound."

Odontotermes flavomaculatus, n.sp.

Imago. Very close to *O. obesus*, with large ocelli approximated to the eyes. Differs from *O. obesus* by a large triangular yellow spot on the fontanelle.

Length with wings	...	... 24·0-25·00 mm.
„ without wings	...	... 12·50 mm.
Breadth of head ...	...	... 2·55 mm.
„ „ pronotum	...	... 2·28 mm.
Length „ „	...	... 1·25 mm.

Soldier. Not distinguishable from the typical soldier of *O. obesus.*

Worker. Agrees completely with the worker of *O. obesus.*

Locality. Assam; between Lukwa and Sibsagar Road; 26th October 1911. "On the wing." C. C. Ghosh coll.

Odontotermes bellahunisensis, n.sp.

Imago. Smaller than *O. obesus.*

Dark-brown. Post-clypeus somewhat tinged with brown but anterior margin of the transverse band scarcely lighter than the remainder of the head. Pronotum with a yellow T-shaped mark. Shoulder-spots indistinct. Posterior part of the T detached from the anterior. The anterior part of meso- and meta-notum also brown. Wings grey-brown with yellowish "subcostal streak."

Hairs moderate.

Head and antennæ as in *O. obesus.* Ocelli separated from the eye by their diameter, relatively small.

Length with wings	...	... 24·00 mm.
„ without „	...	... 14·50 mm.
Breadth of head	...	... 2·32 mm.
„ „ pronotum	...	... 2·16 mm.
Length „ „	...	... 1·14 mm.

Soldier. Morphologically scarcely distinguishable from *O. obesus.* Mandibles perhaps very slightly shorter and stouter.

Length of body ...	...	...	3·5-4·00 mm.
Head with jaws	...	...	1·95 mm.
„ without „	...	...	1·15 mm.
Breadth of head ...	...	...	1·10 mm.
„ „ pronotum	...	...	0·80 mm.

Worker. Perhaps slightly smaller than the worker of *obesus* but otherwise indistinguishable.

Localities :

(1) Madras; Bellary District, Bellahunisi; 30th August 1912. "Issuing from hole in gravelly soil at dusk. No mound at all."

(2) Mysore State; Bangalore; 17th July 1912. "Issuing from hole in ground alongside road (no mound at all) just before heavy rain. Only one hole of exit noticed."

Odontotermes bangalorensis, Holmgr.

Imagines of small dimensions are contained in the collection.

Length with wings	...	...	24·00 mm.
Breadth of head ...	...	...	2·47 mm.

Or do these belong to a new species?

Localities :

South India.

(1) Coimbatore; 4th May 1912. "A half sphæroid-shaped comb about three inches in diameter was found two-and-a-half to three feet below ground when digging up a nest of *Eutermes heimi.* There was no sign of a mound above ground and the species is apparently quite distinct from the ordinary mound-builder here. Some of the soldiers and workers had small mites on their heads. The soldier does not emit a milky fluid from the head."

(2) Coimbatore; 19th May 1912. "Eating piece of rope lying on the ground."

(3) Coimbatore; 5th February 1912. "In cattle-dung."

(4) Coimbatore; 19th September 1912. "On wing at 9-30 P.M."

(5) Coimbatore; 26th May 1912. "Eating a bamboo 'chick' which was touching the ground and which they had plastered over with mud."

(6) Shevaroy Hills, about 2,000 feet; 21st October 1912. "Imagines found floating in pool by roadside. No mound noticed hereabouts."

(7) Shevaroy Hills, about 4,200 feet; 18th October 1912. "At light in evening about 6 P.M."

(8) Bellary District, Hadagalli; 16th July 1912. "At light." Y. Ramachandra Rao coll.

(9) Bellary District, Hadagalli; 1st September 1912. "Nibbling roots of *cholam* (*Andropogon*). Soldier did not emit sticky-stuff."

(10) Bellary District, about halfway between Hospet and Bellahunisi; 30th August 1912. "Under mud galleries run over bark of *babul* tree (*Acacia arabica*). No mound here."

(11) Mysore State, Bangalore; 24th November 1912. "On wing in evening after shower of rain."

Punjab.

(12) Lyallpur; 31st August 1911. G. R. Dutt coll.

Odontotermes wallonensis, Wasm.

Imagines, soldiers, and workers are contained in the collection.

Localities:

South India.

(1) Coimbatore; 3rd February 1912. "Mound-nest with open holes in it."

(2) Coimbatore; 9th May 1912. "Nest under road; no mound on account of traffic, but large open holes leading into the nest."

(3) Coimbatore; 3rd January 1913. "Under log. There was a mound of the usual Coimbatore type, with open chimneys, a few yards away."

(4) Bellary District, on road between Hampasagaram and Hadagalli; 1st September 1912. "From small mound."

(5) Bellary District, Siruguppa; 12th September 1912. "From large mound near river bank. Termitophilous Blattids and Collembola, *Termitoxenia* and *Termitodesmus* occurred in combs and galleries."

(6) Mysore State, Maddur, about 3,000 feet; 18th July 1912. "Mound with open chimneys or, rather, holes into it."

(7) Maddur; 19th July 1912. "Under mud plastered up the stem of a fig-tree."

(8) Bababudin Hills, 4,400 feet; 2nd November 1912. "Large nest by side of path. Queen very large and stout; male small. Soldiers bit hard and left red stains on the fingers. No termitophilous insects found."

(9) Mysore State, Kadur; 31st October 1912. "Under old railway-sleepers."

(10) Kollegal; 20th July 1912. "Mound with open chimneys but these were hardly raised up above the surface of the mound, rather holes in the mound, as in the Coimbatore species."

Bombay.

(11) Poona ; 8th September 1911. " Under logs."

Central Provinces.

(12) Hoshangabad ; 15th September 1911.

Odontotermes (C.) brunneus, Hag.

Soldiers and workers are contained in the collection. They were obtained on 8th September 1911 at Poona from an earth mound.

Odontotermes distans, n. sp.

Imago. Head dark chestnut-brown, the anterior angles, post-clypeus, antennæ and a spot on the fontanelle brown-yellow. A T-shaped mark and two shoulder-spots on the pronotum yellow. Meso- and meta-notum paler than pronotum. Dorsal surface of abdomen dark chestnut-brown, ventral surface much paler. Wings brownish with brown nervures. Hairs moderate. Head partly short-haired, partly with longer bristles. Head broadly oval narrowed anteriorly. Fontanelle punctiform, pale, slightly elevated. Facetted eyes of medium size, somewhat projecting. Ocelli rather large separated from the eye considerably more than their longer diameter. Post-clypeus shorter than half its breadth, anteriorly straight and posteriorly arcuately defined. Antennæ 19-jointed, second joint longer than third, third as long as fourth, fifth shorter than fourth.

Pronotum trapeziform, anteriorly indented in the middle, posteriorly more broadly indented than anteriorly. Mesonotum posteriorly more broadly indented than metanotum.

Wings as in the preceding species. In the forewing the median has about 8-9 branches, the cubitus about 10-13 ; in the hind wing the median has about 3-4 branches, and the cubitus 14-15.

The median of both wings with only anterior connections with the radius-sector.

Length with wings	...	...	27·00 mm.
,, without ,,	...	...	13·00 mm.
,, of forewing	...	...	24·00 mm.
Breadth ,, head ...	...	...	2·02 mm.
,, ,, pronotum	...	...	2·43 mm.
Length ,, ,,	...	...	1·29 mm.

Locality. Shevaroy Hills, Kadiar Rocks, about 4,000 feet ; 15th October 1912. "Winged imagines caught in a spider's web. They were quite fresh and probably on the wing the previous night."

Subgenus *Odontotermes.*

Odontotermes (*O.*) *parvidens*, n. sp.

Imago. Unknown.

Soldier. Most closely allied to *O. feæ*, but distinguished from that species by the fact that the tooth of the left mandible is distinctly smaller and situated in the basal third. Moreover, the head is less strongly narrowed anteriorly; indeed recalling *O. horni.* Antennæ 17-jointed, second joint almost as long as third and fourth combined, third joint shorter than fourth.

Length of body	...	...	... 7·00 mm.
Head with jaws	...	...	... 3·61 mm.
,, without ,,	...	...	... 2·24 mm.
Breadth of head	...	...	... 1·93 mm.
,, ,, pronotum		...	... 1·40 mm.

Worker.

Length of body	...	...	... 5·00 mm.
Breadth ,, head	...	...	... 1·71 mm.
,, ,, pronotum		...	... 0·95 mm.

Localities :

(1) South India ; on road from Mysore to Mercara. "Under log." 15th November 1912.

(2) Punjab ; Dhar, Gurdaspur District ; 21st August 1911. Fateh Mahomed coll.

(3) Bengal ; Chaumahani, Noakhali District ; 6th December 1911. "In old log lying on the ground."

(4) Assam ; Gauhati, Kamakhya Hill (1,800 feet). "On bark of living *tagar* tree" ; 23rd October 1911. C. C. Ghosh coll.

(5) Assam ; Gauhati Town ; 23rd October 1911. "In wood." C. C. Ghosh coll.

Odontotermes assmuthi, Holmgr.

Imago. Agrees wholly with *Odontotermes bellahunisensis* but is perhaps slightly darker and with a smaller head.

Length with wings	...	...	24·00 mm.
,, without ,, ...	...	...	20·00 mm.
,, of forewing ...	...	...	13·00 mm.
Breadth of head ...	...	...	2·28 mm.
,, ,, pronotum	...	...	2·20 mm.
Length ,, ,, ...	...	...	1·10 mm.

Soldier. Soldiers belonging to the same colony as the imago agree completely with typical examples, except that the tooth of the left mandible lies slightly more basad.

Remarks. Doubtful examples were determined by Bugnion as *O. ceylonicus* [under which name this species was consequently referred to and figured in the *Agricultural Journal of India*, Vol. VII, pages 224, 233, fig. 6].

Localities :

(1) South India ; Shevaroy Hills, about 4,500 feet ; 18th October 1912. "Among dead leaves under rotting branch. Soldier emits white sticky-stuff."

(2) Coorg ; Mercara, about 4,000 feet ; 19th November 1912. "In small comb about twelve inches below ground, exposed when cutting a new road ; there was no mound over the comb."

(3) Bihar ; Pusa ; 11th April 1911. "Attacking a log of *sissu* (*Dalbergia sissoo*) lying on the ground."

(4) Punjab ; Gurdaspur ; 20th August 1911. "On wing at 9 A.M. after rain."

Odontotermes malabaricus, n. sp.

Imago. Unknown.

Soldier. Agrees quite well with that of *O. assmuthi* but is larger and more stoutly built.

Length of head	...	...	...	6·00 mm.
Head with jaws	...	...	...	2·62 mm.
,, without ,,	...	..	..	1·71 mm.
Breadth of head	...	...	...	1·37 mm.
,, ,, pronotum		...	...	0·95 mm.

Worker. As in *O. assmuthi*, but larger.

Length of body	...	...	...	4·00 mm.
Breadth ,, head	...	...	...	1·44 mm.
,, ,, pronotum		...	....	0·76 mm.

Localities :

(1) Malabar, Poovanur ; 19th January 1913. "Under mud galleries on coconut stem." Y. Ramachandra Rao coll.

(2) Shevaroy Hills, Yercaud, 4,500 feet ; 20th October 1912. "Under log of *Grevillea* lying on the ground. The soldier emits very little sticky-stuff. There are two sizes of workers."

(3) Mysore ; Bababudin Hills, about 4,000 feet ; 11th November 1912. "In dead *Grevillea* log lying on the ground, eating in under the bark. The soldier has a strikingly large white abdomen and emits white sticky-stuff

Odontotermes (*O.*) *feæ*, Wasm.

Imagines, soldiers and workers are contained in the collection under notice.

Localities :

South India.

(1) Coimbatore; 18th August 1912. "In rotten log hollowed by termites, their galleries filled with wet mud."

(2) Coimbatore; 24th October 1912. "Flying just after sunset, about 6-30 P.M. Probably imago of fungus-growing non-mound-building species. No emergence from nest could be seen. Flight was quite rapid."

(3) Coimbatore; 25th November 1912. "At light in evening."

(4) Coorg; Margalli, 3,500 feet; 17th November 1912. "Under log. Common."

(5) Coorg; Mercara; 21st November 1912. "Running mud galleries up trunk of living tree."

(6) Shevaroy Hills, 4,200 feet; 18th October 1912. "In galleries under bark of dead tree-stump."

(7) On road between Mysore and Mercara; 15th November 1912. "On wing at dusk."

(8) Bangalore; 7th February 1912. "Constructing mud galleries over grass."

(9) Bangalore; 17th July 1912. "Under coating of mud, eating dead wood on ground."

(10) Mysore; Bababudin Hills 4,000—4,700 feet; 3rd November 1912. "In rotten log" and "in dead *Grevillea* log filled with red mud. Soldier emits white sticky-stuff."

Bombay.

(11) Dharwar; 10th February 1912. "Under logs."

(12) Belgaum; 11th February 1912. "In mud galleries up trunk of a mango-tree, eating the bark."

Bengal.

(13) Harra; 2nd October 1911. "In thatch." C. C. Ghosh coll.

Burma.

(14) Maymyo; 16th March 1907. "On *Eucalyptus*."

Odontotermes feæoides, n. sp.

Imago. Unknown.

Soldier. Agrees well with *Odontotermes feæ* but is distinctly smaller. The head is not narrowed anteriorly. The tooth of the left mandible is

placed on the upper edge of the basal third. Antennæ 16-jointed, second joint distinctly longer than third, third longer than fourth. Pronotum distinctly incised anteriorly and posteriorly.

Length of body	6·00 mm.
Head with jaws	3·23 mm.
" without "	2·01 mm.
Breadth of head	1·63 mm.
" " pronotum	1·22 mm.

Worker. Head brown-yellow. Hairs not particularly thick. Fontanelle oval, whitish. Antennæ 17-jointed, second joint longer than third, third as long as fourth and more slender than the following ones. Pronotum faintly incised anteriorly.

Length of body	3·50 mm.
Breadth " head	1·44 mm.
" " pronotum	0·84 mm.

Locality. Coorg, Margalli; 18th November 1912. "Under log lying on ground amongst coffee. Soldier emits transparent sticky-stuff."

Odontotermes anamallensis, n. sp.

Imago. Unknown.

Soldier. Head brown-yellow, mandibles black-brown with brown-yellow basal portion. Body yellowish-white. Hairs on head very thin. Abdominal tergites rather thickly haired with longer bristles on the hinder margin. Head quadrangularly oval, anteriorly indistinctly narrowed. Fontanelle-plate whitish.

Post-clypeus short. Labrum relatively short, anteriorly triangularly pointed. Mandibles stout, slightly bent. Left mandible with a medium-sized anteriorly-directed tooth placed in the middle of the mandible. Right mandible with a slightly uneven inner-margin.

Antennæ 17-jointed, second joint twice as long as third, third shorter and more slender than fourth, fourth as large as fifth.

Pronotum incised anteriorly and posteriorly.

Length of body	6·50 mm.
Head with jaws	3·23 mm.
" without "	2·01 mm.
Breadth of head	1·79 mm.
" " pronotum	1·29 mm.

Smaller Soldier. Antennæ 16-jointed.

Length of body	...	...	...	5·00 mm.
Head with jaws	...	...	...	2·89 mm.
„ without „	...	...	...	1·79 mm.
Breadth of head	...	...	...	1·44 mm.
„ „ pronotum		...	...	0·99 mm.

Worker. Head brown-yellow, body whitish. Hairs as in soldier. Head broadly oval. Fontanelle rounded, small, whitish. Post-clypeus shorter than half its breadth. Antennæ 19-jointed, second joint much longer than third, third more slender and shorter than fourth, fourth as large as fifth.

Pronotum incised anteriorly and posteriorly.

Length of body	..	...	...	5·50 mm.
Breadth „ head	...	...	...	1·71 mm.
„ „ pronotum		...	...	1·03 mm.

Locality.

(1) Anamalai Hills, north slope, about 4,000 feet; 21st January 1912. "In rotten log by roadside."

(2) Anamalai Hills, 3,000 feet; 27th January 1912. "In rotten stump covered with sheets of mud."

Odontotermes mirganjensis, n. sp.

Imago. Unknown.

Soldier. Near the soldier of *Odontotermes dives* forma *celebensis*, but is larger, with a broader head, proportionately shorter mandibles and shorter and more rounded labrum. Tooth of left mandible rather large.

Length of body	...	...	...	7·00 mm.
Head with jaws	...	...	...	3·46 mm.
„ without „	...	...	...	2·24 mm.
Breadth of head	...	...	...	1·90 mm.
„ „ pronotum		...	...	1·48 mm.

Large Worker.

Length of body	...	...	...	5·00 mm.
Breadth of head	...	...	...	1·82 mm.
„ „ pronotum	...	...	...	0·95 mm.

Locality. Bengal, Mirganj; 26th March 1911. "In rotten branch lying on the ground."

Subgenus *Hypotermes*, Holmgr.

Odontotermes (Hypotermes) xenotermitis, Wasm.

Soldiers and workers are included in the collection under notice.

Localities :

(1) Bengal, Dacca ; 10th December 1911. "In mud galleries on tree-trunks."

(2) Assam, Gauhati, Kamakhya Hill (2,000 feet) ; 23rd October 1911. "In wood." C. C. Ghosh coll.

(3) Assam, Shillong, 5,000 feet ; 21st October 1911. "Under a log." "In a pine post." C. C. Ghosh coll.

Genus *Microtermes*, Wasm.

Microtermes globicola, Wasm.

Soldiers and workers are included in the collection under notice.

Localities :

(1) Coimbatore ; 5th May, 1912. "A skep-shaped comb about three inches high and three inches in diameter found just above *kankar* at about four-and-a-half feet below ground. The comb seemed solitary, and contained soldiers, workers, and young. A small termitophilous Collembolan from this comb and two strange-looking Arthropods of very doubtful affinities. This comb is quite distinct in structure and consistency from the ordinary mound-comb. Its exterior surface is convoluted, the horizontally running ridges being very sharply defined. It is rather brittle than soft even when fresh and no white fungus-bodies are visible from the outside."

(2) Coimbatore ; 19th May 1912. "Under a flower-pot in company with Staphylinid beetles."

(3) Coimbatore ; 4th December 1912. "From comb about three inches in diameter and found about eight inches below ground-level (grass field). From the comb was growing a large whitish mushroom which appeared above ground."

(4) Mysore State, Maddur ; 18th July 1912. "Under a log of trimmed wood left lying on the ground. No mound near."

Microtermes obesi, Holmgr.

Imagines are contained in the collection under report.

Localities :

(1) Mysore ; Bangalore ; 6th June 1912. "On the wing." R. D. Anstead coll.

(2) Bihar ; Pusa ; 14th June 1911. "At light in bungalow."

(3) Bihar ; Pusa ; 18th June 1911. "At light, 7-30 P.M."

Microtermes mycophagus, Desn.

Soldiers and workers are included in the collection under report.

Locality. Punjab, Lyallpur ; 15th August, 1911. "Destroying furniture in bungalow."

Microtermes anandi, Holmgr.*

Soldiers and workers are contained in the collection under notice.

Localities :

South India.

(1) Coimbatore ; 28th May 1912. "Under a log of wood lying on the ground, partly in galleries of the earth beneath the log and adhering to it. They had just commenced to tunnel into the log."

(2) Shevaroy Hills, 4,200 feet; 18th October 1912. "In dead tree-stump, tunnelling galleries through mud and wood."

(3) Bellary District, Hadagalli ; 1st September 1912. "In small galleries in ground under a clod of earth. Soldier emits sticky-stuff."

(4) Bellary District, on road between Hospet and Bellahunisi ; 30th August 1912. "Under stone."

(5) Bellary District, Siruguppa ; 13th September 1912.

(6) Coorg ; Sidapur, 3,500 feet ; 16th November 1912. "Under rotten log lying on the ground."

(7) Coorg ; Santikoppa ; 22nd November 1912. "Small fungus-comb in soil."

(8) Mysore ; Kadur ; 31st October 1912. "In tree-stump filled with mud."

Bombay.

(9) Dharwar ; 9th February 1912. "Under log."

Central Provinces.

(10) Hoshangabad ; 18th February 1912. "Attacking ripening wheat in field."

(11) Nagpur ; 5th September 1911. "Under logs."

Punjab.

(12) Gurdaspur ; 19th August 1911. "Under logs."

(13) Multan ; 14th August 1911. "Under mud on trees."

Bihar.

(14) Pusa ; 26th October 1911. "Damaging growing cabbages."

(15) Pusa ; 9th March 1912. "Eating wood buried under ground."

Bengal.

(16) Mirganj ; 26th March 1911. "In dead bamboo."

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* *Note.* There seems to be no doubt but that *M. anandi* is based on soldiers and workers of *M. obesi* (only known in the adult form) and the name *anandi* will consequently sink as a synonym of *obesi*.—T. B. F.

SYNTERMES-GROUP.

Genus *Eutermes*, Fr. Müll.

Subgenus *Eutermes*.

Eutermes indicola, n. sp.

Imago. Unknown.

Soldier. Approaches closely to *Eutermes longicornis.* Frontal profile, however, very slightly less depressed. Head darker and abdominal tergites paler than in *Eutermes longicornis.* Antennæ 12-jointed, third joint longer than second, fourth approximately as long as third.

Length of body ...	...	...	3·00 mm.
Head with frontal tube	...	...	1·79 mm.
„ without „ „	...	...	0·91 mm.
Breadth of head ...	...	...	0·99 mm.
„ „ pronotum	...	...	0·57 mm.

Worker. Colour and hairs as in *Eutermes longicornis.* Sutures of head very distinct. Fontanelle not so large as in *longicornis*, oval, placed in the sagittal suture. Transverse band anteriorly closed in the middle. Post-clypeus shorter than half its breadth, very strongly convex.

Antennæ 13-jointed, third joint very small, second longer than fourth.

Pronotum strongly saddle-shaped, with large anterior flaps, anteriorly not indented.

Length of body ...	...	...	4·10 mm.
Breadth „ head ...	...	...	1·08 mm.
„ „ pronotum	...	...	0·57 mm.

Localities :

(1) Coorg, Mercara ; 21st November 1912. "From globular nest built around a branch."

(2) Anamalai Hills, 4,000 feet ; 22nd January 1912. "Nest in tree ; male and female taken."

(3) Anamalai Hills, 3,000 feet, Kalyana Pandal ; 25th January 1912. "Nest in dead stump."

Eutermes fletcheri, n. sp.

Imago. Unknown.

Soldier. Very close to *Eutermes ceylonicus,* but is larger and has a broader head.

Length of body ...	...	...	3·5-4·00 mm.
Head with frontal tube	...	...	1·52 mm.
„ without „ „	...	...	0·84 mm.
Breadth of head ...	...	...	0·91 mm.
„ „ pronotum	...	...	0·53 mm.

Worker. As in *E. ceylonicus* (larger worker), but larger.

Length of body	...	...	... 5·00 mm.
Breadth ,, head	..	...	... 1·03 mm.
,, ,, pronotum		...	... 0·65 mm.

Locality. Shevaroy Hills, about 4,000 feet; 15th October 1912. "Running black galleries over a rock in the cracks of which were found large numbers of soldiers, workers, nymphs, and young. When disturbed, they march in long files, four or five abreast—nymphs and young also." Also in "galleries over dead tree-stump and in chambers excavated in mud under bark of same."

Eutermes crassicornis, n. sp.

Imago. Unknown.

Soldier. Very close to *Eutermes matangensis.* Head, however, paler. Head very thinly haired. Abdominal tergites with a posterior row of bristles. Shape of head as in *matangensis*, but the frontal tube broader.

Length of body	...	...	... 4·50 mm.
Head with frontal tube		...	... 1·98 mm.
,, without ,, ,,		...	... 1·10 mm.
Breadth of head	...	...	... 1·36 mm.
,, ,, pronotum ...		...	... 0·68 mm.

Worker. As in *Eutermes matangensis*, but antennæ 15-jointed, third joint extremely short, fourth shorter than second, fifth distinctly shorter than fourth.

Length of body	...	...	... 5·00 mm.
Breadth ,, head	...	...	... 1·25 mm.
,, ,, pronotum ...		...	... 0·72 mm.

Localities:

(1) Anamalai Hills, 4,000 feet; 24th January 1912. "Galleries in ironwood."

(2) Coorg, Sidapur, Margalli Estate, 3,500 feet; 17th November 1912. "In gallery leading up tree-trunk. The nest could be seen about twenty feet up the tree."

(3) Mysore, Bababudin Hills, about 4,700 feet; 3rd November 1912. "Galleries over rotten logs and in these logs."

Subgenus *Trinervitermes*, Holmgr.

Eutermes biformis, Wasm.

Imagines, soldiers and workers are contained in the collection under report.

Localitie :

(1) Shevaroy Hills, about 4,500 feet ; 18th October 1912. "Nest under stone. Interior of galleries blackened."

(2) Madras, Saidapet ; July 1907.

Eutermes heimi, Wasm.

Soldiers and workers are included in the collection under report.

Localities :

(1) Coimbatore ; 2nd May 1912. "Nest on grass-covered bank between two fields. There was a small almost flat circular heap of fine grains of earth radiating circularly for a distance of about three inches around a small hole plugged with mud. When this was dug up, several workers were brought up and large and small soldiers came out to repel attack. About half an hour later the workers were busy closing the tunnel again with lumps of mud. The site of the nest looks like a small flattened ant-hill, but the plugged entrance distinguishes it. On 4th and 5th May I dug down to try and reach the nest. Galleries led down to over four-and-a-half feet, at which depth the *kankar*-level was reached and digging was abandoned. In pockets between about one foot and three-and-a-half feet below ground-level there were congregations of soldiers, workers, young, and nymphs. There are apparently *three* forms of workers, (1) a large form with dark head ; (2) a small form with light head ; (3) a pale-yellow form with greatly-dilated abdomen. Possibly this last serves as a food-reserve for young.

"I make this to be *Eutermes heimi*, Wasm. It is very abundant here coming out towards sunset and foraging little bits of dead grass, etc., and sometimes biting off pieces of green grass and carrying them into the nest. The individuals have a very characteristic aromatic odour."

(2) Madras, Triplicane ; 16th October 1907. "At light."

(3) Bellary District, near Hadagalli. "Under a stone."

(4) Bellary District, Hampi Ruins, near Hospet ; 23rd July 1912 : Y. Ramachandra Rao coll.

(5) Mysore State, Maddur ; 18th July 1912. "In the ground at roots of a tree alongside a colony of *Camponotus*."

Subgenus *Grallatotermes*, Holmgr.

Eutermes (*G.*) *grallatoriformis*, n. sp.

Imago. Unknown.

Soldier. Head black-brown, neighbourhood of antennæ and tip of frontal tube rather paler, antennæ dark-brown, rest of body pale-brown.

Hairs are almost completely wanting on the head. Abdominal tergites with some very short bristles on posterior margin. Head, seen from above, triangularly rounded. Frontal tube short, thick, conical, with broader base. Frontal profile rather strongly depressed behind the origin of the frontal tube.

Antennæ 13-jointed, third joint twice as long as second, fourth longer than second.

Pronotum saddle-shaped, not indented anteriorly.

Length of body	...	...	... 4·20 mm.
Head with frontal tube		...	... 1·90 mm.
„ without „ „		...	... 1·10 mm.
Breadth of head	...	...	... 1·18 mm.
„ „ pronotum		...	... 0·65 mm.

Worker. Head black-brown, antennæ rather paler. Pro-, meso- and meta-notum pale-brown. Upperside of body grey-brown, underside paler. Upper part of legs grey-brown, tibiæ and tarsi straw-yellow. Head with very scattered short hairs. Abdominal tergites furnished with scattered, short bristles.

Head broad, rather pentagonally rounded. Sutures of head distinct. Fontanelle not visible. Transverse band pressed in on both sides of the medial line. Post-clypeus rather short.

Antennæ 14-jointed, third joint longer than second, fourth as long as second.

Pronotum saddle-shaped, indented anteriorly.

Length of body	...	... 5·70-5·00 mm.
Breadth „ head	...	... 1·41-1·22 mm.
„ „ pronotum	...	... 0·95-0·72 mm.

Localities:

(1) Anamalai Hills, Tellkadi, leased forest; 11th October 1912. V. S. Iyer coll.

(2) South Kanara, Aryapur; 27th January 1913. "Under long galleries on mango stem." Y. Ramachandra Rao coll.

Remarks. The species is noteworthy in that it reminds one strongly of *Eutermes grallator*, from New Guinea. Probably it belongs to the same subgenus.

Genus *Anoplotermes*, Fr. Müll.

Subgenus *Speculitermes*, Wasm.

Anoplotermes (*S.*) *cyclops*, Wasm.

Workers are contained in the collection under report.

Localities :

(1) Shevaroy Hills, about 3,000 feet ; 14th October 1912. "Under stone by side of path."

(2) Bellary District, Bellahunisi ; 30th August 1912. "Dug from galleries in earth a few inches below low mounds of bare red earth scarcely appearing above ground-level."

(3) Bellary District, Kamalapuram ; 5th September 1912. "Under dead *Agave* stump lying on the ground."

(4) Coorg, Santikoppa ; 22nd November 1912. "In soil, said to damage coffee roots, but this is doubtful."

(5) Mysore, Bababudin Hills, 4,400 feet ; 12th November 1912. "In galleries and chambers in the ground, mostly eight to twelve inches below surface. Many young found, mostly in one large chamber, but no queen could be found."

HAMITERMES-GROUP.

Genus *Hamitermes*, Silv.

Subgenus *Euhamitermes*, Holmgr.

Hamitermes (*Euhamitermes*) *indicus*, n. sp.

Imago. Unknown.

Soldier. Head yellow, mandibles brown towards tips, body whitish.

Head with scattered, short hairs. Abdomen with close-set, short hairs.

Head as in *Hamitermes* (*E.*) *hamatus*, but longer and proportionately more slender. Clypeus, labrum, and mandibles as in *H. hamatus.*

Antennæ 14-jointed, second joint much longer than third, third almost as long as fourth, third and fourth joints inconsiderably more slender than the others.

Pronotum not indented anteriorly.

Length of body	...	...	5·0-5·50 mm.
Head with jaws	...	...	2·51 mm.
„ without „	..	...	1·90 mm.
Breadth of head	...	...	1·14 mm.
„ „ pronotum	...	...	0·72 mm.

Worker. Head yellowish, body whitish.

Hairs rather sparse.

Head oval, narrowed anteriorly.

Fontanelle not visible. Post-clypeus as long as half its breadth.

Mandibles proportionately long and robust with strong teeth.

Antennæ 14-jointed, second joint longer than third, third longer than fourth.

Anterior lobes of pronotum rather large, anteriorly not incised.

Length of body	...	...	5·0-5·50 mm.
Breadth „ head	...	...	0·80 mm.
„ „ pronotum	...	...	0·57 mm.

Locality. Shevaroy Hills, about 4,000 feet; 15th October, 1912. "Under a stone amongst dead leaves. Only one colony found. Evidently a scarce insect."

Genus *Eremotermes*, Silv.

Imago. Head rather arched, oval, anteriorly narrowed. Facetted eye of medium size, rather flattened, not projecting. Ocelli distant from the eye more than half their diameter. Fontanelle distinct, cleft-shaped, pale. Post-clypeus longer than half its breadth, flatly arched. Mandibles with dentition as in *Prohamitermes.* First tooth considerably larger than second.

Antennæ 15-jointed, third joint short and slender.

Meso- and meta-notum rounded posteriorly, with a slight marginal beading.

Wing-membrane with sparse hairs.

Median somewhat approximated to the cubitus.

The systematic position of Eremotermes. The structure of the newly-discovered imagines of *Eremotermes* abundantly confirms the relationship with *Hamitermes* presumed by N. Holmgren inasmuch as it strongly recalls especially such a low representative of the *Hamitermes* Group as *Prohamitermes.* Therefore the section of *Eremotermes* may be classified as a basal branch of the *Hamitermes* stem.

Eremotermes paradoxalis, Holmgr.

Imago. Chestnut-brown, post-clypeus and antennæ yellow. Pro-, meso- and meta-notum with a pale medial line. Wings transparent, brownish. Underside paler. Upper part of legs and tibiæ brown, tarsi yellow.

Hairs moderately thick. Wing-membrane with sparse hairs.

Head somewhat arched, oval, narrowed anteriorly. Eyes of medium size, somewhat flattened, ocelli separated from eye by more than half their diameter.

Fontanelle distinct, cleft-shaped, pale. Post-clypeus longer than half its breadth, flatly arched.

Antennæ 15-jointed, third joint very short and more slender than second and fourth, second almost twice as long as fourth.

Pronotum, with a cruciform marking, about as long as half its breadth, with rounded rectangular anterior angles and with very obtusely rounded posterior angles. Anterior and posterior margins incised.

Median somewhat approximated to cubitus, with two apical branches. Cubitus with about nine single branches of which the inner six are thicker.

Length with wings	9·80 mm.
" without wings	4·90 mm.
" of forewing	8·40 mm.
" " head	0·95 mm.
Breadth " "	0·76 mm.
" " pronotum	0·65 mm.
Length " "	0·34 mm.

Localities :

(1) Coimbatore ; 9th May 1912. "Emerging from small holes in the ground after a shower of rain, at about 4 P.M. The soldiers and workers did not appear above ground but were obtained by turning up the earth where the winged imagines were emerging."

(2) Central Provinces, Hoshangabad ; 17th September 1911. "On outskirts of mound-nest No. 9."

(3) Bihar, Pusa ; 25th June, 1911. "On wing, 5-30 to 6-30 P.M. over grass lawn."

Eremotermes fletcheri, n. sp.

Imago. Agrees closely with *E. paradoxalis* but is much larger and more coarsely built. Meso- and meta-notum broader posteriorly.

Length with wings	10·00 mm.
" without wings	6·00 mm.
" of forewing	7·50 mm.
" " head	1·14 mm.
Breadth " "	0·84 mm.
" " pronotum	0·76 mm.
Length " "	0·46 mm.

Soldier. Closely allied to *E. paradoxalis*, but however more coarsely built with a little more depressed [" wenig niedrigerem "] head and with proportionately longer mandibles.

Antennæ 14-jointed, third joint rather thicker than second and fourth, third longer than second, fourth shorter than second.

Length of body	4·50 mm.
Head with jaws	1·98 mm.
" without "	0·99 mm.
Breadth of head	0·91 mm.
" " pronotum	0·57 mm.

Worker. Little differentiated from *E. paradoxalis.* Second antennal joint long, but not so long as third and fourth combined.

Length of body	3·90 mm.
Breadth „ head	0·87 mm.
„ „ pronotum	0·53 mm.

Locality. Coimbatore; 12th May 1912. "Issuing from hole in ground at 0·30 P.M. during sunshine."

MIRO-CAPRITERMES-GROUP.

Genus *Mirotermes*, Wasm.

Subgenus *Mirotermes*, Wasm.

Mirotermes (*M.*) *obtusus*, n. sp.

Imago. Unknown.

Soldier. Nearly allied to *Mirotermes brevicornis.* Frontal projection obtuse, rectangularly truncated anteriorly.

Length of body	4·50 mm.
Head with frontal projection (without mandibles)	1·21 mm.
Breadth of head	0·91 mm.
„ „ pronotum	0·53 mm.

Worker. Agrees completely with *Mirotermes brevicornis.*

Length of body	3·40 mm.
Breadth „ head	0·87 mm.
„ „ pronotum	0·53 mm.

Locality. Bellary District, Hospet; 29th August 1912. "Found in soil between surface and a depth of about one foot when digging up a nest of *Termes convulsionarius.* Proportion of soldiers is about ten per cent."

Mirotermes fletcheri, n. sp.

Imago. Unknown.

Soldier. Very closely allied to *Mirotermes* (*M.*) *ceylonicus*, but is smaller and with the head more depressed anteriorly.

Length of body	3·80 mm.
Head without mandibles	1·37 mm.
Breadth of head	0·91 mm.
„ „ pronotum	0·53 mm.

Worker. Agrees completely with *Mirotermes* (*M.*) *ceylonicus.*

Length of body	3·80 mm.
Breadth „ head	0·80 mm.
„ „ pronotum	0·49 mm.

Localities :

(1) Bellary District ; Hospet Taluq ; Hampi Ruins, about 1,200 feet ; 23rd July 1912. "One soldier and four workers found under a stone." Y. Ramachandra Rao coll.

(2) Bellary District ; Hadagalli ; 2nd September 1912. "In galleries in the soil under a stone. About ten workers to every soldier."

Genus *Capritermes*, Wasm.

Capritermes fletcheri, n. sp.

Imago. Unknown.

Soldier. Head whitish-yellow, left mandible black, right brown. Body whitish. Head with sparse hairs.

Abdominal tergites with longer bristles posteriorly.

Head flattened, cylindrical. Fontanelle punctiform. Labrum long, considerably longer than broad, deeply incised anteriorly.

Mandibles shorter than head. Antennæ 14-jointed, third joint almost as long as second, fourth shorter than third.

Pronotum saddle-shaped, not incised anteriorly.

Length of body	4·45 mm.
Head with jaws	2·51 mm.
" without "	1·48 mm.
Breadth of head	0·95 mm.
" " pronotum	0·65 mm.

Worker. Head white, body whitish. Hairs sparse. Post-clypeus inconsiderably shorter than half its breadth, strongly distended. Antennæ 13-jointed, third joint considerably shorter than second, not sharply defined from fourth, fourth rather shorter than second, but longer than third. Pronotum not incised.

Length of body	3·25 mm.
Breadth " head	0·89 mm.
" " pronotum	0·49 mm.

Localities :

(1) Malabar, Puthupadi Forest ; 22nd January 1913. "Under a rotting bamboo." Y. Ramachandra Rao coll.

(2) Anamalai Hills, about 4,000 feet ; 22nd January 1912. "Colony in dead log."

(3) Mysore, Bababudin Hills, 4,400 feet ; 12th November 1912. "In galleries and chambers two to ten inches below soil at roots of coffee."

Capritermes punjabensis, n. sp.

Imago (wingless). Head chestnut-brown, post-clypeus and antennæ brownish-yellow. Pronotum and abdominal tergites paler than the head. Meso- and meta-notum as well as abdominal sternites still paler brownish, the last yellowish medially.

Hairs short and plentiful.

Head oval, narrowed anteriorly. Facetted eyes of medium size, rather projecting. Ocelli rather large, separated from eye by half their diameter. Post-clypeus shorter than half its breadth, rather arched.

Antennæ 15-jointed, second joint as long as third and fourth combined, third shorter than fourth.

Pronotum, with paler marking, almost semi-circular, anteriorly straight, posteriorly incised.

Length of body	...	...	...	6·00 mm.
Breadth " head	...	...	...	1·03 mm.
" " pronotum		...	...	0·80 mm.
Length " "	...	...	...	0·53 mm.

Locality. Punjab, Lyallpur ; 31st August 1911. G. R. Dutt coll.

Remarks. Very closely allied to *C. nemorosus* but is distinguishable by its smaller facetted eyes and 15-jointed antennæ.

Capritermes incola, Wasm.

Soldiers and workers are contained in the collection under report.

Localities :

(1) Nilgiri Hills, Kethi, 6,500 feet. "In a potato-field." Y. Ramachandra Rao coll.

(2) Coorg ; Mercara, about 4,000 feet ; 21st November 1912. "In soil under sods and at roots of grass."

(3) Mysore, Bababudin Hills, 4,600 feet ; 2nd November 1912. "Galleries at roots of grass, under stones."

MICROCEROTERMES-GROUP.

Genus *Microcerotermes*, Wasm.

Microcerotermes fletcheri, n. sp.

Imago. Unknown.

Soldier. Head brownish-yellow, darker anteriorly. Body whitish. Head with very sparse hairs. Abdominal tergites with short, sparse hairs. Head elongated, cylindrical. Frons strongly sloped, medially depressed,

faintly bilobed with obtuse-angled lobes. Labrum pentagonal, tongue-shaped, rather longer than broad. Mandibles with in-bent tips, irregularly and strongly serrated.

Antennæ 13-jointed, third joint shorter than fourth, fourth shorter than second.

Pronotum saddle-shaped, very inconsiderably incised anteriorly.

Length of body	5·00 mm.
Head with jaws	2·47 mm.
„ without „	1·71 mm.
Breadth of head	0·95 mm.
„ „ pronotum	0·65 mm.

Worker. Two sizes.

Larger Worker. Head yellow, body whitish. Hairs short. Head broadly oval. Fontanelle not visible. Post-clypeus rather large, arched, considerably longer than half its breadth.

Antennæ 13-jointed, third joint longer than second, second longer than fourth. Pronotum saddle-shaped, anterior margin not incised.

Length of body	4·00 mm.
Breadth „ head	0·87 mm.
„ „ pronotum	0·57 mm.

Smaller Worker. Head white, body white. Otherwise as is Larger Worker, with exception of antennæ.

Antennæ 13- or 14-jointed, third joint inconsiderably shorter than second, fourth shorter than third.

Length of body	2·89 mm.
Breadth „ head	0·80 mm.
„ „ pronotum	0·42 mm.

Locality. Mysore, Bababudin Hills, about 4,100 feet; 12th November 1912. "Under dead log of sandalwood by path-side. Red clayey soil. Termites in galleries under mud along lower side of log. Very few soldiers."

Microcerotermes heimi, Wasm.

Soldiers and workers are included in the collection under report.

Locality. Mysore, Bababudin Hills, about 4,200 feet; 6th November 1912. "In galleries excavated in dead branches of a thorny bush. These galleries were run up the stem, the pithy centre being eaten out, but no mud taken in, although in one place there was a transverse barrier made (apparently) of woody matter. Very few soldiers in comparison with number of the workers, less than ten per cent., probably about five per cent."

ON A COLLECTION OF SPHECOIDEA SENT BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA, BIHAR.

BY

ROWLAND E. TURNER, F.Z.S., F.E.S.

[Received for publication on the 15th March, 1917.]

THE notes in the following paper are taken from a collection forwarded to me for naming by Mr. T. Bainbrigge Fletcher, Imperial Entomologist, and form part of the collection of the Agricultural Research Institute at Pusa. The types of the new species are lodged in the British Museum. The collection is of much interest, showing the presence of a small Palæarctic element as far east as the plains of Bihar, and adding representatives of several genera to the Indian fauna. I have added descriptions of three or four new Indian species in the British Museum Collection.

Neofoxia scutellatus Turn.

Psenulus (?) *scutellatus* Turn. Ann. & Mag. Nat. Hist. (8) X, p. 54, 1912. ♀.

Neofoxia scutellatus Turn. Ann. & Mag. Nat. Hist. 8) XIX, p. 128, 1916.

Hab. Cairns, N. Queensland.

One female from Dacca.

Differs from the type in the yellow margin of the pronotum, in the position of the first recurrent nervure which in the Indian form is interstitial with the first transverse cubital, in the Queensland form just beyond it, and in the slightly lesser constriction of the base of the second dorsal segment. *N. xanthognathus* Rohw. from Luzon is also nearly allied, but is a more slender insect with the median segment much more coarsely sculptured.

Hab. Dacca ; January.

It is remarkable that the Indian form should be nearer to the Queensland than to the Luzon form ; probably it will form a subspecies,

but I consider it better to wait till more material is available before definitely naming it.

Stigmus aterrimus sp. n.

♀. Nigra; callis humeralibus albidis; tegulis apice fuscis; alis hyalinis, iridescentibus, venis nigris.

Long. 6 mm.

♀. Front broad, concave, with a longitudinal carina reaching to the base of the clypeus; eyes very slightly divergent towards the vertex, separated at the base of the clypeus by a distance about half as great again as the length of the scape. Front subopaque, vertex smooth and shining; eyes separated from the posterior margin of the head by a distance about equal to their own breadth; ocelli in an almost equilateral triangle, the posterior pair more than twice as far from the eyes as from each other and about the same distance from the posterior margin of the head. Antennæ very slender, inserted nearer to the eyes than to each other. Pronotum transverse, smooth and shining, the margins raised, the anterior angles pointed; mesonotum and scutellum smooth and shining, a transverse crenulate groove at the base of the scutellum. Propleuræ irregularly striated; mesopleuræ shining, with a few scattered punctures. Median segment coarsely longitudinally striated on the basal third; beyond the striated basal portion is an enclosed triangular space reaching to the apex of the dorsal surface, the enclosed portion transversely striated with a median longitudinal carina; the sides of the segment obliquely striated; the apical slope minutely punctured, with a distinct median groove. Petiole as long as the hind femur and trochanter combined. Abdomen shining, sparsely and minutely punctured. Hind tibiæ smooth. Second cubital cell twice as long on the cubitus as on the radius; stigma nearly three times as long as its greatest breadth; recurrent nervure received just beyond the middle of the first cubital cell.

Hab. Coonoor, Nilgiri Hills, 5,000 ft., (*G. R. Dutt*), April.

This is very distinct from *cuculus* Nurse in the form of the stigma, the sculpture of the median segment, the longer petiole, the smooth hind tibiæ and the much greater size, also in the colour of the legs, mandibles and antennæ; from *congruus* Walk. in the same points of colour, and in the sculpture of the median segment, and the greater breadth of the front. I look on *S. niger* Motsch, as a synonym of *congruus*. The head of *congruus* is shorter and more narrowed behind the eyes than in the present species.

Diodontus fletcheri sp. n.

♀. Nigra; mandibulis, apice excepto, callis humeralibus, tegulis basi, femoribus apice, tibiis anticis, tibiis intermediis et posticis basi, tarsisque flavis; alis hyalinis, venis fuscis.

Long. 4—5 mm.

♀. Labrum deeply incised at the apex; clypeus almost transverse on the apical margin, with a row of three well defined teeth. Head finely punctured, more closely on the front than on the vertex; posterior ocelli as far from each other as from the eyes and further from the posterior margin of the head than from each other. Thorax very finely punctured; propleuræ with two strong carinæ; upper portion of the mesopleuræ very coarsely reticulate. Dorsal surface of the median segment strongly longitudinally striated, the striæ diverging towards the apex; the sides of the segment closely striated; the apical slope indistinctly reticulate, with a distinct median groove. Abdomen shining, closely microscopically punctured. Hind tibiæ strongly, intermediate less strongly spined, the apical joints of the tarsi more or less infuscate. Second recurrent nervure received just beyond the middle of the second cubital cell, the space between the first transverse cubital nervure and the second recurrent nervure nearly twice as great as the length of the second abscissa of the radius.

Hab. Ootacamund, 7,500 ft., (*T. Bainbrigge Fletcher*), December.

This appears to be very near *D. reticulatus* Cam. from Deesa, which I have not seen, but Cameron makes no mention of the teeth on the clypeus, and there are also colour differences. The sculpture, however, appears to be very similar. Cameron in his descriptions of Indian *Diodontus* seems to mistake the labrum, when not concealed by the mandibles, for the clypeus.

Dolichurus gilberti Turn.

Dolichurus gilberti Turn. Ann. & Mag. Nat. Hist. (8) X, p. 365, 1912. ♀♂

Hab. Khasi Hills, 5,000 ft., (*Turner*), May; Lebong, 5,000 ft., (*Lefroy*), June. Mr. Lefroy took the female preying on small *Blattidæ*, showing that the habits are similar to those of *Ampulex.*

Dolichurus taprobanæ Sm.

Dolichurus taprobanæ Sm. Trans. Ent. Soc. London, p. 304, 1869. ♀.

Hab. Pusa, (*G. R. Dutt*), December.

Apparently ranges over the whole of India.

Sceliphron deforme Sm.

Pelopœus deformis Sm. Cat. Hym. B. M. IV, p. 231, 1856.

Pelopœus curvatus Sm. Trans. Zool. Soc. London VII, p. 187, 1870.

Sceliphron lineatipes Cam. Ann. & Mag. Nat. Hist. (7) V, p. 36, 1900.

Bingham treats Smith's names as synonyms of *formosum* Sm., which is Australian, but I consider that *deforme* must stand, at least as a subspecies.

Sceliphron pictum Sm.

Pelopœus pictus Sm. Cat. Hym. B. M. IV, p. 231, 1856. ♂.

Hab. Lahore, (*G. R. Dutt*), April to July; Taru, Peshawar, (*T. Bainbrigge Fletcher*), May; Pusa, Bihar,* (*G. R. Dutt*), May. Also in the British Museum from Manora; Karachi, (*F. W. Townsend*), May; Fao, S. Persia, (*D. Cumming*); Muscat, Arabia, (*A. S. G. Jayakar*).

This species always has the scutellum yellow and the greater part of the median segment also yellow. I formerly followed Bingham in regarding this as a highly coloured variety of *S. bilineatum* Sm., but a close examination of the type of *bilineatum* inclines me to regard that species as merely a variety of *madraspatanum* Fab., in which the median segment is usually entirely black, whilst in the type of *bilineatum* there is a short longitudinal fascia on each side and a spot near the apex. Mr. Fletcher informs me that the mud nests of *pictum* and *madraspatanum* differ in shape.

Sceliphron madraspatanum Fabr.

Sphex maderospatana Fabr. Spec. Insect, p. 446, 1781.

Sceliphron madraspatanum Klug. Neu Schr. Ges. naturf. Fr. Berlin III, p. 565, 1801.

Pelopœus madraspatanus Fabr. Syst. Piez, p. 203, 1804.

Pelopœus separatus Sm. Ann. & Mag. Nat. Hist. (2) IX, p. 47, 1852.

Sceliphron kohli Sickm. Zool. Jahrb. VIII, p. 218, 1894.

Var. *Pelopœus bilineatus* Sm. Ann. & Mag. Nat. Hist. (2) IX, p. 47, 1852.

The abdomen of the type of *bilineatum*, and also of that of *separatum*, is very distinctly aciculate, but other specimens of *madraspatanum* show this

* There is apparently an error in the citation of the locality Pusa. Nests were brought to Pusa from Lahore by Mr. G. R. Dutt and wasps emerged from these nests at Pusa and were probably wrongly labelled "Pusa." T. B. F.

character in a varying degree, though it is abnormal in the species. I am inclined to consider that the character shows in stylopized specimens only. Bingham (Fauna British India, Hymen., I, p. 239) under *S. bilineatum* seems to describe the head and abdomen of *deforme* Sm. and the thorax and legs of *pictum*, giving the typical *bilineatum* as a variety. It is just possible that *bilineatum* is distinct from both *madraspatanum* and *pictum*. The type was taken at Bombay.

Sphex (*Parapsammophila*) *dives* Brullé.

Ammophila dives Brullé. Exped. sc. Morée Zool. II, p. 369, 1832. ♀.

Ammophila limbata Kriechb. Verh. zool. bot. Ges. Wien XIX, p. 597, 1869. ♀♂.

Var. *Ammophila festiva* Sm. Cat. Hym. B. M. IV, p. 211, 1856. ♀.

Ammophila nigritaria Walk. List of Hymen. in Egypt, p. 18, 1871. ♀♂.

Hab. Rohtak, Punjab, August 6, 1909, (*G. R. Dutt*).

Also from S.-E. Europe, N. Africa and Arabia. The red colour on the abdomen is more extensive in the Indian specimen than in any other that I have seen, but there is no other difference. The Indian form is *A. elegans* Sm.

Sphex (*Psammophila*) *tydei* Guill.

Hab. Karachi; Multan, (*G. R. Dutt*), April.

This wide ranging species extends into N.-W. India. I think it will prove to be the species described by Bingham as *Ammophila læta*. The type of *læta* is said to be in the British Museum, but is not marked, though there is a specimen of *tydei* from Chaman, the type locality, named by Bingham himself.

Cerceris rejecta sp. n.

♀. Nigra; mandibulis, apice excepto, clypeo, fronte subantennis, orbitis internis externisque latissime, supra interruptis, fronte fascia mediana longitudinali, vertice macula obliqua utrinque, prothorace, tegulis, mesopleuris maculis magnis duabus, scutello, postscutello, segmento mediano macula magna utrinque, segmentis dorsalibus 1—5 fascia lata interrupta, ventralibus primo secundoque macula magna mediana, tertio fascia interrupta, mesosternoque fascia longitudinali utrinque flavis; pedibus ferrugineis flavo-variegatis;

segmenti mediani area basali macula parva utrinque, abdomine, hic illic nigro intaminato, antennisque ferrugineis; alis pallide flavo-brunneis, apice infuscatis; clypeo brevi, apice late emarginato, porrecto; mesopleuris minutissime tuberculatis; segmento mediano area basali nitida, lateribus crasse punctata; segmento ventrali secundo area basali elevata nulla.

Long. 15 mm.

♀. Clypeus short and broad, porrect and very widely emarginate at the apex. Frontal carina strongly raised; the antennæ inserted three times as far from the anterior ocellus as from the base of the clypeus; cheeks as broad as eyes, without a spine. The whole insect punctured, more coarsely on the vertex and mesopleuræ than elsewhere, most closely on the dorsal surface of the abdomen; pygidial area coarsely granulate, twice as long as broad, the sides almost parallel, very broadly rounded at the apex; ventral segments shining, very sparsely punctured, the second segment without a raised basal area. The tubercle on the mesopleuræ is very small and is situated very near the mesosternum. Petiole of the second cubital cell very short, scarcely more than one-third as high as the second cubital cell. Mandibles with a large tooth on the inner margin.

Hab. Chapra, Bihar, (*Mackenzie*).

The form of the clypeus somewhat resembles that of *C. orientalis* Sm. but is much less strongly emarginate than in that species and the lamina is not free or nearly so strongly porrect.

Cerceris renominata nom. nov.

Cerceris opulenta Turn. Journ. Bombay Nat. Hist. Soc. XXI, p. 809, 1912. (nec Morice, Trans. Ent. Soc. London, p. 82, 1911.)

The name *opulenta* having been used by Morice for a variety of *C. dacica*, it is necessary to rename my species.

Philanthus sumptuosus sp. n.

♀. Nigra; mandibulis, apice excepto, clypeo, fronte sub antennis, macula bilobata inter antennas, scapo subtus, tegulis, postscutello fascia angusta subinterrupta, segmentis dorsalibus 2—5, ventralibus 3—5 fascia angusta, interrupta, apicali, tibiisque antice flavis; flagello subtus, segmentis abdominalibus duobus basalibus, tarsisque ferrugineis; alis hyalinis, venis testaceis.

♂. Feminæ similis, fronte dimidio inferiore, genis, pronoto fascia, callis humeralibus, mesopleuris maculis duabus, segmento dorsali primo macula

utrinque, secundo macula maxima utrinque, 3—6 fascia continua apicali, femoribus apice, tibiis tarsisque flavis; flagello articulis 5—7 omnino rufo-flavidulis, 1—4 flavis supra nigro-lineatis. Variat scutello flavo.

Long. ♀, 11—12 mm.; ♂, 10—11 mm.

♀. Clypeus very broadly rounded at the apex, without teeth, shining, with a few scattered and very shallow punctures. Eyes emarginate, reaching to the base of the mandibles, separated on the vertex by a distance about equal to the length of the four basal joints of the flagellum. Antennæ inserted a little further from each other than from the eyes, the second joint of the flagellum nearly twice as long as the third, and more than three times as long as its apical breadth. Head and thorax finely and closely punctured, the punctures larger and sparser on the disc of the mesonotum, very sparse on the scutellum; median segment closely punctured, with a shallow longitudinal sulcus. Basal dorsal segment a little narrower than the second, finely and sparsely punctured, the remaining segments almost smooth, the sixth segment broadly rounded at the apex. Basal joint of the fore tarsi with five spines, excluding a very short spine near the base. Cubitus of the hindwing interstitial with the transverse median nervure.

♂. Somewhat more finely punctured than the female; the seventh dorsal segment narrowly rounded at the apex.

Hab. Pusa, Bihar, (*G. R. Dutt*), March and April. 6 ♀♀, 3♂♂.

This is very near *ordinarius* Bingh., but in that species the antennæ are stouter and shorter, the second joint of the flagellum being scarcely more than twice as long as its apical breadth, the sixth dorsal segment is narrowly emarginate at the apex and the two basal abdominal segments are broadly black at the apex. *P. scrutator* Nurse and *P. avidus* Bingh. are also related, though not quite as closely.

Bembex persimilis sp. n.

♂. Niger; labro, clypeo, mandibulis, apice excepto, scapo, flagello subtus, orbitis latis anticis et posticis, fronte parte inferiore, pronoto, callis humeralibus, mesonoto lateribus, strigis duabus discoidalibus, et maculis duabus parvis apicalibus, mesopleuris, scutello fascia angusta apicali et lateribus, postscutello fascia apicali, segmento mediano fascia mediana curvata, postice emarginata, lateribusque, segmentis dorsalibus 1—7 fascia latissima, segmentis 1—3 vel antice emarginata, vel bisinuata, vel maculis duabus nigris includente,

segmentis ventralibus fere omnino, pedibusque flavidulis; metatarso antico dilatato, extus lobulis nigris prædito; alis hyalinis, venis testaceis.

Long. 14 mm.

♂. Eyes diverging very slightly towards the clypeus, almost parallel; front between the antennæ distinctly carinate. Seventh, eighth and ninth joints of the flagellum feebly prominent beneath, but without distinct spines, apical joint slightly curved and rounded at the apex. Basal joint of the fore tarsi dilated, with four black lobes on the outer margin, a close row of many fine spine-like hairs along the outer margin, but no definite spines except the two at the apex. Spine of the fore tibiæ with a translucent rounded lobe. Fore femora unarmed, intermediate femora rather feebly serrate beneath. Basal joint of the intermediate tarsi somewhat broadened and flattened at the apex; intermediate tibiæ slightly produced at the apex. Second and sixth ventral segments each with an elevated longitudinal tubercle, seventh with a longitudinal median carina. Seventh dorsal segment very broadly rounded at the apex, coarsely and sparsely punctured. Hindwings with only one vein springing from the apex of the median cell.

Hab. Akalgarh, Punjab, (*G. R. Dutt*), March.

Closely allied to the Algerian *B. barbara* Handl., but differs in the much more extensive pale markings, in the presence of many fine setæ instead of a few long spines on the basal joint of the fore tarsi, in the very distinct serration of the intermediate femora and in the absence of lateral carinæ on the seventh ventral segment. The colour in the two specimens before me is reddish, evidently affected by cyanide, I have therefore assumed that the normal colouring is yellowish.

Bembex relegatus sp. n.

♂. Niger; mandibulis, apice excepto, labro, clypeo, orbitis anticis et posticis latis, fronte fascia longitudinali et fascia transversa ante ocellos, scapo subtus, prothorace, thorace subtus, pleuris, mesonoto lateribus et strigis duabus longitudinalibus apice fascia transversa conjunctis, scutello postscutelloque fasciis apicalibus, segmento mediano fascia curvata, segmentis dorsalibus 1—6 fascia lata, 1—3 macula nigra utrinque includente, segmentis ventralibus 1—4, segmento ventrali quinto fascia emarginata, sexto macula utrinque, pedibusque flavidulis; alis hyalinis, venis testaceis.

Long. 12 mm.

♂. Eyes almost parallel; front between the antennæ with a distinct, but not strongly raised, carina; antennæ normal as far as the sixth joint of the flagellum, the remaining joints missing; anterior legs normal, the basal joint of the fore tarsi with six spines; intermediate femora serrate beneath on the apical half; intermediate tibiæ and tarsi normal. Second ventral segment with a low longitudinal carina not reaching the base or apex and not produced into a tubercle; sixth ventral segment with a low triangular tubercle at the apex; seventh with three longitudinal carinæ. Seventh dorsal segment broad, narrowly truncate at the apex, very sparsely punctured on the apical half. Genital stipes narrow, rounded at the apex. Only one vein springing from the apex of the median cell of the hindwing.

Hab. Multan, Punjab, (*G. R. Dutt*), April.

Superficially this resembles *B. radoszkowskyi* Handl., but may be distinguished by the very different armature of the ventral segments. Both species belong to the group of *B. oculata* Latr.

The female, which was taken in the same month by Mr. Dutt at Lahore, is coloured as in the male, but with the spots on dorsal segments 2—3 not wholly enclosed by the yellow band, and the sixth dorsal segment is almost entirely yellow, narrowly subtruncate at the apex. The second ventral segment is sparsely punctured in the middle.

Bembex oculata Latr.

Bembex oculata Latr. Hist. Nat. Crust. et Insect, XIII, p. 302. 1805.

Hab. Karachi, (*E. Comber*), September and October; Nasik, (*E. Comber*).

This wide ranging Palæarctic species must be included in the Indian fauna.

Stizus erythrogaster sp. n.

♂. Niger; abdomine rufo-ferrugineo, segmentis duobus apicalibus infuscatis; scapo apice extremo, flagello articulo ultimo apice, tegulisque fuscis; alis fuscis, anticis apice, extra cellula radiali, hyalinis.

Long. 13 mm.

♂. Eyes strongly convergent towards the clypeus, which is strongly convex and almost transverse at the apex. Antennæ inserted about twice as far from the anterior ocellus as from the base of the clypeus, second joint of the flagellum as long as the third and fourth combined, slender; the apical joints gradually increasing in thickness, joints 8—10 broader than long; apical

joint shorter than the penultimate, slightly curved and truncate at the apex. Head sparsely and shallowly punctured, a distinct longitudinal carina between the antennæ, the front covered with silver pubescence. Thorax strongly rugosely punctured, the same sculpture extending to the median segment and pleuræ. Abdomen elongate, finely and closely punctured, more coarsely on the three apical segments than at the base; seventh dorsal segment a little produced at the apex and narrowly truncate. The hyaline margin of the forewing reaches to the apex of the radial cell and very nearly touches the third transverse cubital nervure, narrowing rapidly beyond the cubitus. Anal cell of hindwing extending far beyond the origin of the cubitus.

Hab. Chapra, Bihar, (*Mackenzie*).

This is a slender species closely allied to *conscriptus* Nurse in sculpture and colour, but the forewing has the apex hyaline as in *blandinus* Sm., which is a more robust and less coarsely sculptured species. The clypeus in the present species is less distinctly emarginate than in *conscriptus*, and in that species the seventh dorsal segment is rounded and not produced at the apex. Both belong to the group of *tridentatus* Fabr.

Stizus proximus Handl.

Stizus proximus Handl. Sitzungsber. Akad. Wiss. Wien. CI, p. 45, 1892. ♂♀.

A single female taken by Mr. Fletcher at Kalyana Pandal, Anamalais, S. India, 3,000 feet, in January. There are specimens in the British Museum from the Cocos Islands.

Arpactus (*Hoplisoides*) *remotus* sp. n.

♀. Nigra; clypeo, orbitis anticis late, pronoto margine, callis humeralibus, scutello fascia transversa, segmento dorsali primo fascia apicali interrupta, secundo, quarto quintoque fascia apicali, segmentoque ventrali secundo fascia lata apicali flavis; mandibulis basi, macula sub alis, segmento dorsali primo, pedibusque ferrugineis; tarsis intermediis flavo-maculatis; alis hyalinis, venis fusco-ferrugineis, area radiali infuscata.

Long. 7 mm.

♀. Eyes only slightly convergent towards the clypeus; antennæ short, distinctly thickened towards the apex. Head finely and rather sparsely punctured; mesonotum and scutellum very closely and deeply punctured, the punctures very large; pleuræ coarsely, but less closely punctured; the

longitudinal and transverse carinæ of the mesosternum well developed. Median segment with the enclosed basal area well defined and marked with about ten longitudinal carinæ, the rest of the segment rugosely punctured. Abdomen strongly, but not very closely punctured; the first segment narrowed to the base, but no longer than the second, only half as broad at the apex as the second segment; sixth dorsal segment coarsely rugose. Spines of the tibiæ small and delicate, anterior tarsi not ciliated. Cubitus of the hindwing originating at the apex of the anal cell.

Hab. Jummoo, Punjab, (*G. R. Dutt*), May.

Easily distinguished from other Indian species of the subgenus *Hoplisoides* by the much coarser sculpture. The Indian species of *Hoplisoides* already recorded are *pictus* Sm., *feæ* Handl., *capitatus* Nurse and *intrudens* Nurse.

Arpactus (*Dienoplus*) *vividus*, sp. n.

♂. Niger; prothorace, mesothorace, scutello, postscutelloque rufo-ferrugineis; mandibulis, antennis, tegulis, pedibusque ferrugineis; clypeo, orbitis anticis late, segmentoque dorsali secundo macula apicali utrinque flavis; alis hyalinis, iridescentibus, venis ferrugineis.

Long. 5 mm.

♂. Eyes very slightly convergent towards the clypeus; head shining, minutely and sparsely punctured. Thorax shining, with a few fine scattered punctures, the groove at the base of the scutellum crenulate. Median segment with the basal area well defined and coarsely longitudinally striated; the remainder of the segment coarsely, but irregularly obliquely striated. First dorsal segment short and broad, smooth and shining; second finely and sparsely punctured; the remaining segments closely and minutely punctured. The mesopleuræ are distinctly but sparsely punctured.

Hab. Lahore, Punjab, (*G. R. Dutt*), April.

This is very distinct both in colour and sculpture from *ornatus* Sm., the only other Indian species belonging to the subgenus. The same differences divide it from all other species of the subgenus occurring in the Palæarctic region, the sculpture of the median segment being much coarser than in any of them.

This subgenus was formerly known as *Arpactus* but Jurine's name *Arpactus* with *A. mystaceus* L. for the type appears to have priority over *Gorytes* Latr. which applies to the same group. *Arpactus* therefore should be used for the genus, and cannot apply to the present subgenus, which does not

include *mystaceus*. *Dienoplus* Fox appears to be the name which must be used for the subgenus.

Alyson annulipes Cam.

Alyson annulipes Cam. Mem. Manchester Lit. & Phil. Soc. XLI, No. 13, p. 21, 1897. ♂.

Cameron's description applies to the male, though he states that he is describing a female. That sex, however, has the scutellum, median segment and the basal half of the first abdominal segment ferruginous. This species is not identical with *Alyson ruficolle* Cam. from Ceylon.

Hab. Pusa, Bihar, (*G. R. Dutt*), Aprii and May; Panch Mahals, (*E. Comber*), August; Poona, (*R. Wroughton*).

Nysson dubitatus Turn.

Nysson dubitatus Turn. Ann. & Mag. Nat. Hist. (8) XIV, p. 255, 1914. ♀.

Described from Coimbatore specimens, taken in July. A single male from Pusa, taken in March, is similar to the female, but has the apical margins of ventral segments 2—5 with a fringe of long fulvous hairs in the middle; the sixth dorsal segment has a tooth on each side near the apical angles; the seventh is truncate at the apex, with a short blunt tooth on each side at the apical angles. In these points it comes very near the male of *basalis* Sm., from which it differs in the colour of the basal abdominal segment and of the ventral fringes; the seventh dorsal segment is transverse between the apical teeth in *dubitatus*, but bluntly produced in *basalis*. Both species belong to the group of *N. scalaris* Illig., to which *N. decoratus* Turn. from Coimbatore also belongs. In all these species the anal cell of the hindwing is short, terminating far before the origin of the cubital nervure.

Nysson dutti, sp. n.

♂. Niger; mandibulis basi, clypeo, scapo subtus, flagelli articulo basali macula apicali subtus, pronoto fascia interrupta, callis humeralibus, scutello linea basali, segmentisque dorsalibus tribus basalibus macula transversa apicali utrinque flavis; tegulis testaceis; abdomine segmento primo, segmento ventrali secundo, pedibusque ferrugineis; alis hyalinis, venis testaceis.

Long. 4 mm.

♂. Apical joint of the flagellum slightly curved, longer than joints ten and eleven combined, but shorter than those joints combined with the ninth; all

the joints, except the apical and the second, much broader than long. Front between the antennæ concave, not carinate, just below the base of the antennæ the front terminates in a short bilobed process which is raised above the base of the clypeus. Head finely and closely punctured, clothed with yellowish grey pubescence ; no marginal carina behind the eyes. Mesonotum and scutellum more strongly punctured than the head ; propleuræ finely striated, mesopleuræ coarsely rugose ; postscutellum coarsely longitudinally striated ; enclosed area of the median segment coarsely striated, the striæ not reaching the apex, the spines at the apical angles acute, but not very long. Abdomen finely punctured, the punctures becoming finer and closer on the apical segments ; second ventral segment rounded at the base, shining and strongly punctured ; seventh dorsal segment with a spine on each side at the apical angles, the margin between the spines transverse. Hind tibiæ smooth, the legs more or less marked with yellow. Anal cell of the hindwing terminating just beyond the origin of the cubital nervure. There is no fringe of hairs on the ventral abdominal segments.

Hab. Chapra, Bihar, (*Mackenzie*). One male.

Closely allied to the European *N. variabilis* Chevr., but differs in the shorter, stouter, antennæ ; in the yellow clypeus, and in some other details of colour. I do not think it can be the male of *N. horni* Strand, which that author compares with *variabilis*, on account of the much smaller size, the different colour of the clypeus, legs and nervures and the finer puncturation of the head.

Entomognathus nanus Cam.

Crabro nanus Cam. Mem. Manchester Lit. & Phil. Soc. (4) III, p. 274, 1890.

This species has the mandibles excised and the eyes hairy, and is in all respects a true *Entomognathus*.

Hab. Chapra, Bihar, (*Mackenzie*).

Entomognathus chapraensis, sp. n.

♀. Nigra ; mandibulis basi, scapo, pronoto margine postico, callis humeralibus, tegulis, postscutelloque flavis ; pedibus pallide ferrugineis flavo-variegatis ; alis hyalinis, venis testaceis ; thorace crasse punctato.

Long. 5 mm.

♀. Clypeus subporrect and narrowly emarginate at the apex, with two small teeth on each side close to the apical angles ; mandibles deeply excised

on the outer margin. Eyes separated at the base of the clypeus by a distance scarcely exceeding half the length of the scape, the facets no larger in front than at the sides, very slightly hairy. Head finely and not very closely punctured, the front and clypeus clothed with silver pubescence, a longitudinal groove from the anterior ocellus reaching the concave portion of the front; posterior ocelli further from each other than from the eyes, the space between them and the eyes smooth and shining, with a narrow oblique groove almost reaching the eyes. Mesonotum and scutellum very coarsely punctured, mesopleuræ punctured-rugose and thinly clothed with delicate silver pubescence. Enclosed area of the median segment obliquely striated, the striæ rather low and far apart, the enclosing carinæ strong, the space between them and the lateral carinæ of the dorsal surface almost smooth, with a few indistinct striæ. Abdomen shining, microscopically punctured, subsessile; sixth dorsal segment broadly triangular. Recurrent nervure received close to the middle of the cubital cell, transverse cubital nervure joining the radial cell just before two-thirds from the base, the radial cell broadly truncate at the apex.

Hab. Chapra, Bihar, (*Mackenzie*).

Easily distinguished from *nanus* by the larger size, and much coarser sculpture of the thorax.

Entomognathus isolatus, sp. n.

♀. Nigra, nitida; mandibulis basi, scapo, pronoto margine postico, callis humeralibus, scutello postscutelloque flavis, pedibus flavis, coxis femoribusque intermediis et posticis infuscatis; tegulis testaceis; alis hyalinis, venis testaceis.

Long. 3 mm.

♀. Mandibles deeply excised on the outer margin near the base, acute at the apex; clypeus short and broad, not carinate or toothed, transverse at the apex. Antennæ inserted further from each other than from the eyes; front smooth and shining, vertex finely and sparsely punctured. Eyes separated at the base of the clypeus by a distance equal to about three-quarters of the length of the scape, not hairy, the facets in front very large; posterior ocelli half as far again from each other as from the eyes, the space round each ocellus broadly depressed, a narrow, impressed, oblique line from each posterior ocellus to the eye, a distinct depression between the posterior ocelli. Thorax much narrower than the head, the pronotum rounded at the sides; mesonotum subopaque, very finely, but not closely, punctured, the parapsidal furrows

shallow but distinct. Enclosed area of the median segment finely obliquely striated, the apical slope with a deep median sulcus, smooth in the middle, very finely punctured on the sides; the pleuræ almost smooth. Abdomen minutely punctured; sixth dorsal segment triangular, flat; the first segment subsessile. Hind tibiæ with a row of spines. Radial cell rather narrowly truncate at the apex, the transverse cubital nervure received at about one-third from the base; recurrent nervure received much before the middle of the cubital cell.

Hab. Pusa, Bihar, (*T. V. Rama Krishna*), June. 1♀.

This is not a typical *Entomognathus*, the eyes being without hairs and the facets very large in front, resembling *Crossocerus* rather than the groups allied to *Lindenius*. But the mandibles being simple at the apex, and excised on the outer margin, it must, I think, be placed in *Entomognathus*, in spite of the differences in the eyes and neuration. In general facies it closely resembles *Lindenius saundersi* Kohl, an Algerian species, from which it differs in the excision of the mandibles, the position of the recurrent nervure, and the greater size of the facets of the eyes in front.

Rhopalum iridescens, sp. n.

♂. Niger; scapo subtus, callis humeralibus, tarsisque anticis et intermediis, apice infuscatis, coxisque apice, albis; alis hyalinis, splendide iridescentibus, venis nigris.

Long. 5—6 mm.

♂. Clypeus short and broad, the apical margin transverse, clothed with silver pubescence. Antennæ inserted nearer to the eyes than to each other, eyes separated at the base of the clypeus by a distance equal to the length of the scape; a groove running from the anterior ocellus towards the base of the clypeus. Ocelli in an equilateral triangle, the posterior pair much nearer to each other than to the eyes, but a little nearer to the eyes than to the posterior margin of the head. Subopaque on the head and thorax, shining on the median segment and abdomen, without visible punctures, the mesopleuræ sparsely clothed with white pubescence; median segment without a distinctly enclosed area, but with a triangular space at the base more shining than the rest of the segment and divided by a shallow longitudinal sulcus, which is continued more distinctly on the apical slope. Petiole long and very slender, a little swollen at the apex, as long as the hind femur and trochanter combined. Hind tibiæ rather strongly swollen on the apical half. Radial

cell rather broadly truncate at the apex, receiving the transverse cubital nervure before one-third from the base; the recurrent nervure received close to the middle of the cubital cell.

Hab. Gulmarg, Kashmir, (*Col. F. W. Thomson*).

This is quite distinct from *elongatus* Dudgeon, having the front broader and the colour different, the wings also much more highly iridescent. It does not answer to the descriptions of either *petiolatus* Nurse or *aswad* Nurse, both of which seem to belong to *Rhopalum*, but which have no white markings.

Dasyproctus funestus sp. n.

♂. Niger; scapo subtus, pronoto linea utrinque, callis humeralibus, segmento dorsali secundo macula parva utrinque, segmento quinto fascia utrinque, femoribus anticis intermediisque extremo apice, tibiis anticis intermediisque supra, tarsisque anticis intermediisque basi flavis; antennis pedibusque fuscis; alis hyalinis, iridescentibus, venis fuscis.

Long. 5—6 mm.

♂. Clypeus covered with silver pubescence, with a low longitudinal carina, the apical margin slightly produced in the middle. Eyes with much larger facets in front than elsewhere, separated from each other at the base of the clypeus by a distance not quite equal to half the length of the scape; the antennæ inserted nearer to the eyes than to each other. Posterior ocelli far apart, but nearly as far from the eyes as from each other, and distinctly nearer to each other than to the posterior margin of the head. Opaque and smooth, a transverse crenulated groove at the base of the scutellum, a vertical crenulated groove on the mesopleuræ below the tegulæ; the postscutellum longitudinally rugose; the dorsal surface of the median segment coarsely rugose, with short longitudinal striæ at the base, the sides of the segment more shining than the rest of the insect and very finely and indistinctly striolate. Petiole as long as the hind femur and trochanter combined, distinctly, but not very strongly, swollen at the apex, second segment very narrow at the base, broadened strongly to the apex. Transverse cubital nervure received just before the middle of the radial cell, which is obliquely truncate at the apex; recurrent nervure received at about two-thirds from the base of the cubital cell.

Hab. Pusa, Bihar; March.

"With dead Acalyptrate flies in the stem of *Dicliptera* sp."

This is a smaller species than *orientalis* Cam., and may be distinguished from all other Indian species of the group known to me by the more sombre colouring and by the much coarser sculpture of the median segment.

Crabro (*Clytochrysus*) *sexcinctus* Fabr.

This common European species occurs in the mountains on the North-West frontier of India; differing from West European specimens in the yellow colour of the scutellum in the female, but not otherwise. Specimens from Gulmarg, Kashmir, have the abdominal fasciæ interrupted, but in a specimen from Hazara only the fascia of the third segment is interrupted.

Hab. Europe and Western Asia. Hazara District, Dungagali, 8,000 ft., May 21—24, (*T. Bainbrigge Fletcher*); Gulmarg, Kashmir, (*Col. F. W. Thomson*).

Crabro (*Clytochrysus*) *violaceipennis* Cam. from Sikkim is very near this species, but in addition to colour differences the sculpture of the basal area of the median segment is different, the striation in the female being more strongly defined in *violaceipennis*.

Oxybelus nigritulus sp. n.

♀. Nigra ; pronoto linea utrinque, callis humeralibus, lamellis postscutelli, segmento dorsali primo macula transversa utrinque, secundoque macula minuta utrinque flavis ; scutello postscutelloque linea obliqua apicali utrinque pallide flavidula ; tibiis anticis extus fusco-ferrugineis ; tarsis articulo apicali testaceis ; alis hyalinis, venis ferrugineis ; tegulis testaceis.

♂. Feminæ similis ; flagello subtus in medio, tarsisque anticis sordide ferrugineis, tibiis anticis extus, intermediis posticisque basi, femoribus anticis intermediisque subtus, segmentis dorsalibus secundo tertioque macula transversa utrinque, quartoque macula minutissima utrinque flavis.

Long. ♀, 7 mm. ; ♂, 6 mm.

♀. Clypeus flattened, not convex, the anterior margin transverse and smooth ; head closely and very distinctly punctured ; eyes separated on the front by a distance equal to about two-and-a-half times the length of the scape, the space between and above the base of the antennæ shining and almost smooth ; posterior ocelli almost three times as far from each other as from the eyes ; thorax rather strongly punctured, mesopleuræ rugose ; scutellum more sparsely punctured, with a median carina, which is continued on the post-scutellum ; lamellæ of the postscutellum rather small, rounded on the outer, straight on the inner side ; mucro of the median segment narrow, three times

as long as the greatest breadth, concave, emarginate at the apex; the surface of the median segment obliquely striated at the base, transversely at the apex, with the usual triangular area and marginal carinæ, the sides of the segment longitudinally striated. Abdomen closely and finely punctured, the sixth dorsal segment more coarsely punctured and very narrowly truncate at the apex; the three basal segments distinctly depressed at the apex; ventral surface shining, sparsely punctured.

♂. Clypeus broadly emarginate at the apex, produced into a spine in the middle of the emargination, the lateral angles of which are produced into very short and blunt spines. Front rather narrower than in the female. Seventh dorsal segment rather broadly truncate at the apex.

Hab. Shillong, Assam, 5,000—6,000 ft., April to June, (*Turner*).

This may be distinguished from other Indian species by the black legs of the female and by the form of the clypeus. It is allied to the European *O. nigripes* Oliv., but differs in the female in the clypeus and in the narrower pygidial area. It may prove to be only a geographical race of *nigripes*, the differences in the male being very slight.

Oxybelus agilis Sm.

Oxybelus agilis Sm. Cat. Hym. B. M., IV, p. 387, 1856. ♂.

Oxybelus sabulosus Sm. Cat. Hym. B. M., IV, p. 388, 1856. ♀.

These are undoubtedly sexes of one species, differing much in the form of the clypeus, as is often the case in this genus; the mucro is also broader in the female.

The species is nearly allied to the European *O. trispinosus* Fabr., but not identical.

Oxybelus pictiscutis Cam.

Oxybelus pictiscutis Cam. Journ. Bombay Nat. Hist. Soc., XVIII, p. 302, 1908.

This seems to be one of the commonest species of the genus in Northern India and the Punjab. Like *agilis* it belongs to the group of *trispinosus*; but may be distinguished from *agilis* by the large yellow spots on the scutellum, and on the middle of the postscutellum. I consider that *O. aurifrons* Cam. (Journ. Bombay Nat. Hist. Soc., 1902) is the male of this species, but the name cannot stand, having been used by Smith in 1856 for a Brazilian species.

Oxybelus furcifer sp. n.

♀. Nigra ; mandibulis basi, scapo, flagello articulo primo, pronoto margine postico, tegulis, scutello macula magna utrinque, postscutello, lamellis, segmentis dorsalibus 1—4 fascia transversa utrinque, femoribus apice, tibiis tarsisque flavis ; tibiis posticis apice nigro-maculatis ; segmento mediano basi acute bispinoso ; alis hyalinis, venis testaceis.

♂. Feminæ similis ; segmento dorsali quinto utrinque flavo-fasciato ; segmentis quarto quintoque angulis apicalibus spina brevi armatis.

Long. ♀♂. 4—5 mm.

♀. Mandibles long and slender ; clypeus convex, but not distinctly carinate, the apical margin transverse, slightly depressed and shining, a low tubercle in the middle before the margin. Front about twice as broad as the length of the scape and first joint of the flagellum combined ; posterior ocelli separated from each other by a distance about three times as great as that separating them from the eyes ; scutellum with a median carina, rather strongly punctured ; postscutellar laminæ as broad as long, strongly rounded on the outer side. Two acute and moderately long spines spring from the base of the median segment ; the vertical surface of the segment is obliquely striated at the base, transversely at the apex, with the usual marginal carinæ and triangular enclosed space. Abdomen finely punctured ; the sixth dorsal segment very narrowly rounded at the apex. Mesonotum and pleuræ closely and finely punctured, the sides of the median segment longitudinally striated at the base, almost smooth at the apex.

♂. Clypeus rather strongly bisinuate at the apex ; the striation of the median segment coarser than in the female ; the fourth and fifth abdominal segments armed with a small spine on each side at the apical angles ; seventh dorsal segment shallowly emarginate at the apex.

Hab. Chapra, (*Mackenzie*) ; Pusa, (*G. R. Dutt*), July.

Easily distinguished from other Indian species of the genus by the two spines of the median segment which replace the usual mucro.

Oxybelus transiens sp. n.

♀. Nigra ; mandibulis, apice excepto, antennis, clypeo, tibiis, femoribus anticis intermediisque, femoribus posticis apice, pygidioque apice ferrugineis ; pronoto, tegulis, scutello postice nigro-marginato, postscutelli lamellis,

as long as the greatest breadth, concave, emarginate at the apex; the surface of the median segment obliquely striated at the base, transversely at the apex, with the usual triangular area and marginal carinæ, the sides of the segment longitudinally striated. Abdomen closely and finely punctured, the sixth dorsal segment more coarsely punctured and very narrowly truncate at the apex; the three basal segments distinctly depressed at the apex; ventral surface shining, sparsely punctured.

♂. Clypeus broadly emarginate at the apex, produced into a spine in the middle of the emargination, the lateral angles of which are produced into very short and blunt spines. Front rather narrower than in the female. Seventh dorsal segment rather broadly truncate at the apex.

Hab. Shillong, Assam, 5,000—6,000 ft., April to June, (*Turner*).

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Oxybelus furcifer sp. n.

♀. Nigra ; mandibulis basi, scapo, flagello articulo primo, pronoto margine postico, tegulis, scutello macula magna utrinque, postscutello, lamellis, segmentis dorsalibus 1—4 fascia transversa utrinque, femoribus apice, tibiis tarsisque flavis ; tibiis posticis apice nigro-maculatis ; segmento mediano basi acute bispinoso ; alis hyalinis, venis testaceis.

♂. Feminæ similis ; segmento dorsali quinto utrinque flavo-fasciato ; segmentis quarto quintoque angulis apicalibus spina brevi armatis.

Long. ♀♂. 4—5 mm.

♀. Mandibles long and slender ; clypeus convex, but not distinctly carinate, the apical margin transverse, slightly depressed and shining, a low tubercle in the middle before the margin. Front about twice as broad as the length of the scape and first joint of the flagellum combined ; posterior ocelli separated from each other by a distance about three times as great as that separating them from the eyes ; scutellum with a median carina, rather strongly punctured ; postscutellar laminæ as broad as long, strongly rounded on the outer side. Two acute and moderately long spines spring from the base of the median segment ; the vertical surface of the segment is obliquely striated at the base, transversely at the apex, with the usual marginal carinæ and triangular enclosed space. Abdomen finely punctured ; the sixth dorsal segment very narrowly rounded at the apex. Mesonotum and pleuræ closely and finely punctured, the sides of the median segment longitudinally striated at the base, almost smooth at the apex.

♂. Clypeus rather strongly bisinuate at the apex ; the striation of the median segment coarser than in the female ; the fourth and fifth abdominal segments armed with a small spine on each side at the apical angles ; seventh dorsal segment shallowly emarginate at the apex.

Hab. Chapra, (*Mackenzie*) ; Pusa, (*G. R. Dutt*), July.

Easily distinguished from other Indian species of the genus by the two spines of the median segment which replace the usual mucro.

Oxybelus transiens sp. n.

♀. Nigra ; mandibulis, apice excepto, antennis, clypeo, tibiis, femoribus anticis intermediisque, femoribus posticis apice, pygidioque apice ferrugineis ; pronoto, tegulis, scutello postice nigro-marginato, postscutelli lamellis,

segmentis dorsalibus 1—5 fascia transversa apicali utrinque, coxis, trochanteribus tarsisque flavis; alis hyalinis, venis fusco-ferrugineis.

Long. 4—5 mm.

♀. Clypeus without a carina, the apical margin almost transverse. Eyes diverging both towards the clypeus and the vertex, rather further from each other at the base of the clypeus than on the vertex. Head finely punctured, the front clothed with pale golden pubescence. Thorax very closely and rather finely punctured; scutellum almost smooth, with a median carina on the apical half, the narrow black hind margin slightly depressed and coarsely punctured; postscutellar laminæ rather short, with an incurved spine at the apex; mucro lamellar, short, as broad at the apex as long, broader at the apex than at the base, the apex widely emarginate, smooth. Posterior slope of the median segment finely transversely striated, with the usual marginal carinæ and triangular enclosed space, the sides of the segment finely striated. Abdomen finely and closely punctured; the apical segment more coarsely punctured and clothed with stiff golden setæ, very narrowly rounded at the apex.

Hab. Chapra, Bihar, (*Mackenzie*).

Although the mucro is broad and only slightly recurved at the sides, I do not look on this species as belonging to the subgenus *Notoglossa.*

Oxybelus (*Notoglossa*) *lamellatus* Oliv.

Oxybelus lamellatus Oliv. Encycl. method. Insect, VIII, p. 593, 1811.

Oxybelus arabs Lep. Hist. Nat. Insect. Hymen. III, p. 212, 1845. ♀.

Oxybelus forticarinatus Cam. Journ. Bombay Nat. Hist. Soc., XVIII, p. 304, 1908.

Hab. Gujranwala, Punjab, (*G. R. Dutt*), April; Pusa, (*G. R. Dutt*), July; Chapra, (*Mackenzie*).

The extent of the markings on the abdomen is very variable. I doubt if *O. squamosus* Sm. is distinct from this species, but have not seen the type. Specimens from Ceylon have the second dorsal segment more finely punctured than in *arabs*, and probably form a subspecies, to which perhaps the name *squamosus* may apply, but I think as the type was from Barrackpore it is more likely to be identical with Pusa specimens. The species belongs to the subgenus *Notoglossa* Dahlb., and ranges as far west as Gibraltar and Mogador.

Oxybelus (Notoglossa) linguifera sp. n.

♀. Nigra, aureo-sericea ; mandibulis basi, pronoto linea utrinque, callis humeralibus, tegulis, postscutello, segmentisque dorsalibus 1—4 macula transversa utrinque flavis ; clypeo apice, antennis, pedibusque ferrugineis ; alis hyalinis, venis testaceis ; mucrone magna, linguiforme, apice acuta.

Long. 5 mm.

♀. Clypeus transverse at the apex, with a strong carina from the base not reaching the apex. Head and thorax evenly and very distinctly punctured, each puncture bearing a very short golden hair. Eyes separated on the front by a distance about equal to three times the length of the scape ; posterior ocelli far apart, four times as far from each other as from the eyes. Mesopleuræ very coarsely punctured ; scutellum with a median carina ; lamellæ of the post-scutellum small and narrow, pointed. Mucro large, linguiform, about twice as long as the greatest breadth, narrowed to the apex and pointed, with a median carina and fine transverse striæ, the margins distinctly raised. Median segment longitudinally striated on the sides, obliquely and irregularly at the base of the vertical portion, transversely at the apex, the enclosed area somewhat cordiform in shape. Abdomen finely and closely punctured, the apical segment very broadly triangular, feebly emarginate at the apex, the extreme apex ferruginous ; ventral segments finely and rather closely punctured.

Hab. Gujranwala, Punjab, (*G. R. Dutt*), April.

Easily distinguished from the two other Indian species of the subgenus *Notoglossa*, (*lamellatus* Oliv. and *robustus* Cam.), by the pointed mucro, which is not emarginate as in the other species.

Dimorpha (olim *Astata*) *maculifrons* Cam.

Astata maculifrons Cam. Mem. Manchester Lit. & Phil. Soc. (4) II, p. 149, 1889. ♂.

Astatus interstitialis Cam. Journ. Bombay Nat. Hist. Soc., XVII, p. 1010, 1907. ♀.

Dimorpha (olim *Astata*) *fletcheri*, sp. nov.

♀. Nigra ; abdomine rufo-ferrugineo ; scapo apice, mandibulis, apice excepto, tibiis anticis, tarsisque anticis ferrugineis, tibiis tarsisque intermediis et posticis fusco-ferrugineis ; alis hyalinis, venis testaceis, stigmate brunneo-testaceo.

Long. 7 mm.

♀. Head shining, sparsely punctured, the vertex almost smooth, the front sparsely clothed with long grey pubescence. Antennæ stout, the third joint of the flagellum a little longer than the second. Mesonotum sparsely punctured and clothed with long grey hairs anteriorly, the posterior half and the scutellum smooth and shining; mesopleuræ closely punctured. Median segment strongly longitudinally striated, the apical slope coarsely transversely striate-rugose, the sides of the segment smooth at the base, irregularly striated at the apex. Sixth dorsal segment narrowly triangular; the sides raised, forming marginal carinæ. Abdomen smooth and shining. Radial cell short, broadly truncate at the apex, a little shorter on the costa than the combined length of the second and third abscissæ of the radius; the third cubital cell longer on the radius than on the cubitus, third abscissa of the radius as long as the first and second combined. The cubital margin of the second cubital cell receives the recurrent nervures at one-third and two-thirds from the base.

Hab. Pusa, Bihar, (*G. R. Dutt*), March; Chapra, Bihar, (*Mackenzie*); Nagpur.

A specimen taken by Mr. Fletcher at Ootacamund, 7,500 feet, in December, has the radial cell very slightly shorter, but does not seem to differ otherwise. The species seems to be very near *A. quettæ* Nurse, but that species is entirely smooth and shining, except on the median segment, and has the front strongly convex. The sculpture of the median segment differs much from *lubricatus* Nurse. *Astatus* Latr., corrected by him to *Astata*, was published in 1796 without any species, the name being used by Panzer in 1801 in *Tenthredinidæ*, and Jurine's name *Dimorpha* was published with *boops* as the type before Latreille assigned any species to *Astata*. So that *Dimorpha* must stand, quite independently of any question as to the validity of the publication of the Erlangen list (*vide* Morice and Durrant, Trans. Ent. Soc., London, p. 395, 1915).

Palarus indicus Nurse.

Palarus indicus Nurse. Journ. Bombay Nat. Hist. Soc., XV, p. 4, 1903.
Hab. Pusa, April; Deesa (*Nurse*).

Palarus funerarius Moraw.

Palarus funerarius Moraw. Hor. Soc. ent. Ross, XXIII, p. 136, 1889.
Palarus quiescens Nurse. Journ. Bombay Nat. Hist. Soc., XV, p. 5, 1903.
Hab. Lyallpur, Punjab, (*G. R. Dutt*), August.
Originally described from Mongolia.

Dinetus cereolus Morice subsp. *politus* subsp. nov.

♀. Differs from the typical Egyptian form in the much more shining surface, especially on the head and the median segment ; in the almost obsolete striation of the middle of the dorsal surface of the median segment, the striation being much more distinct in the type ; in the more extended black area on the median segment ; in the lesser extent of the yellow area on the front, which in *cereolus* reaches the anterior ocellus, but does not extend nearly so high in the present form ; and in the black occiput, the yellow band behind the eyes being continued across the occiput in the type, but not in the present form. The colour in the Indian form is reddish testaceous, but this is probably due to cyanide.

Hab. Chapra, Bihar, (*Mackenzie*).

The typical form was taken at Cairo. The genus has not been previously recorded from India.

Larra simillima Sm.

Larra simillima Sm. Cat. Hym. B. M., IV, p. 275, 1856. ♀.

Larra fuscipennis Cam. Mem. Manchester Lit. and Phil. Soc. (4) II, p. 126, 1889. ♂.

I look on these as only sexes of one species. Bingham's key is misleading, the transverse ridge on the front being distinct in the female as well as in the male. The pronotum is very much longer in the female, showing a distinct dorsal surface, not sunk below the level of the mesonotum as in the male. A series of males from Chapra in the Pusa collection show every gradation in the colour of the three basal abdominal segments from almost entirely red to entirely black. The species is very closely allied to the European *L. anathema* Rossi, which it replaces in India, also to the Chinese *L. similis* Mocs. and to the Japanese *L. simplipennis* Sm.

Hab. Chapra ; Pusa ; Tirhut.

Notogonia nigrita Lep.

Tachytes nigrita Lep. Hist. Nat. Insect. Hymen., III, p. 241, 1845. ♀. ♂.

Hab. Multan, Punjab, (*G. R. Dutt*), April.

This common Mediterranean species has not previously been recorded from India.

Notogonia nigra v. d. Lind.

Larra pompiliformis Panz. Fauna Insect. German, IX, 106, 1809 (nec Panz. 89, 1805).

Tachytes nigra v. d. Lind. Nouv. Mem. Acad. Sci. Bruxelles, V, p. 23, 1829.

Larrada agilis Sm. Cat. Hym. B. M., IV, p. 284, 1856. ♀.

Larra nigriventris Cam. Mem. Manchester Lit. & Phil. Soc. (4) II, p. 127, 1889. ♀.

Larra nana Bingh. Fauna British India, Hymen., I, p. 200, 1897. ♀

Larra iridipennis Cam. Ann. & Mag. Nat. Hist. (7) V, p. 26, 1900. ♀.

I do not think that these can be divided, even subspecifically. Very closely allied are *N. vigilans* Sm. from China, and *N. obliquetruncata* Turn. and *N. recondita* Turn. from Australia The latter is probably a subspecies.

Hab. Central and South Europe; North Africa (*pompiliformis*); Gambia (*agilis*); Cape Verde Islands; N. Nigeria; Nyasalana; N.-E. Rhodesia; Madagascar (*agilis*); Chapra, Bihar; Khasi Hills (*nigriventris*); Tenasserim (*nana*).

Not previously recorded from India under Panzer's name.

Notogonia reticulata Cam.

Laptolarra reticulata Cam. Ann. & Mag. Nat. Hist. (7) V, p. 31, 1900.

Hab. Barrackpore; Chapra; Matheran.

This is a subspecies of *N. nigricans* Walk. which is Egyptian, but the mesonotum is more finely punctured in reticulata.

Parapiagetia erythropoda Cam.

Tachytes erythropoda Cam. Mem. Manchester Lit. and Phil. Soc. (4) II, p. 135, 1889. ♀.

This is not a *Tachytes* but a *Parapiagetia*. Cameron's description is quite sufficient, and there is also a female from Deesa in the British Museum identified by him. Males in the Pusa collection from Rohtak, Punjab, and Pusa closely resemble *P. wickwari* Turn. from Ceylon, differing only in the distinctly shorter and broader petiole. But a female from Ceylon has the first abdominal segment shorter and less distinctly petiolate than in North Indian specimens and also has the femora black, except at the apex. A

specimen of the male in the Pusa collection from Samalkote, Madras, is identical with Ceylon specimens. On the whole I am inclined to regard *wickwari* as a subspecies only. The tarsi of the female are short, but the fifth joint is unusually long, exceeding the length of the basal joint, and the tarsal ungues are long. The spines of the fore tarsi are very short, the hind tibiæ have a row of strong spines.

Tachysphex substriatulus sp. n.

♀. Nigra ; mandibulis, apice excepto, scape apice, tegulis, femoribus apice, tibiis tarsisque ferrugineis ; segmentis abdominalibus margine apicali anguste decoloratis ; alis hyalinis, venis pallide ferrugineis.

Long. 5·5 mm.

♀. Clypeus very narrowly transversely depressed at the apex, thinly clothed with delicate silver pubescence which extends on to the front. Head subopaque, not punctured, smooth, with an obscure depressed line from the base of the clypeus to the anterior ocellus. Ocellar prominence not divided by a sulcus, entire ; above it is an oblique impressed line on each side, continued posteriorly from the junction on to the vertex. Antennæ rather stout, the second and third joints of the flagellum subequal, but short ; eyes separated on the vertex by a distance nearly equal to the combined length of the four basal joints of the flagellum. Pronotum very steeply sloped ; mesonotum shining, almost smooth ; scutellum smooth ; mesopleuræ minutely punctured, with a very deep vertical groove anteriorly. Median segment very delicately transversely striolate on the dorsal surface and on the posterior slope. Abdomen almost smooth, longer than the thorax and median segment combined ; pygidial area elongate triangular, finely and sparsely punctured. Comb of the fore tarsi almost absent, with a few very short and feeble spines. Radial cell rather narrowly truncate at the apex, extending as far as the apex of the third cubital cell ; second and third abscissæ of the radius subequal, the fourth nearly as long as the three first combined. The space between the recurrent nervures on the cubitus is less than the second abscissa of the radius.

Hab. Lahore, Punjab, (*G. R. Dutt*), April.

This is near *inventus* Nurse in colour, but differs in the sculpture of the median segment, and in the absence of a sulcus on the ocellar prominence.

Tachysphex sericea Sm.

Larrada sericea Sm. Cat. Hym. B. M., IV, p. 285, 1856. ♀.

Lyrops fluctuata Gerst. Monatsber. Akad. Wiss. Berlin, p. 510, 1857. ♀.

Tachysphex selectus Nurse. Journ. Bombay Nat. Hist. Soc., XIX, p. 514, 1909. ♂.

Tachysphex ferrugineipes Cam. Sjöstedt, Kilimandjaro-Meru Exp. II, p. 289, 1910.

Cameron is possibly correct in identifying this species as *Tachytes ferrugineipes* Lep., which name has priority over Smith's; but the original description leaves much doubt.

Hab. Gambia; Angola; Pakasa, N. Rhodesia; Dunbrody, Cape Colony; Chapra, Bihar; Biskra, Algeria; Albania; Corfu.

The species identified by Smith as *ferrugineipes* Lep. is a *Notogonia*, which is more probably correct. *T. sericea* has not been previously recorded from India, except under Nurse's name.

Tachysphex bengalensis Cam.

Tachysphex bengalensis Cam. Mem. Manchester Lit. & Phil. Soc. (4) II, p. 144, 1889. ♀.

Bingham's specimen from Amherst, Tenasserim, from which apparently the description in the *Fauna of India* was taken, is different to specimens from Pusa, these having the fourth joint of the tarsi much broader than long, thus closely resembling *brevitarsis* Kohl., from which they differ in the colour of the nervures and the more distant and coarser puncturation of the mesonotum.

Tachysphex syriacus Kohl.

Tachysphex syriacus Kohl. Verh. zool.-bot. Ges. Wien, XXXVIII, p. 146, 1888. ♂.

Tachysphex peculator Nurse. Journ. Bombay Nat. Hist. Soc., XIX, p. 515, 1909. ♂.

Hab. Deesa, (*Nurse*), November; Karachi, (*Comber*), October.

Ranges over the Southern Mediterranean region, and also through tropical Africa from the Gambia to Mozambique.

Tachysphex lilliputianus sp. n.

♂. Niger, minutus, sparse albopilosus; segmento mediano brevissimo, longitudinaliter rugoso-striato; segmentis dorsalibus 1—3 fascia angusta apicali albopilosa; alis hyalinis, iridescentibus, venis fuscis.

Long. 3·5 mm.

♂. Clypeus almost transverse at the apex, punctured at the base, narrowly depressed and shining. Second joint of the flagellum distinctly shorter than the third, only about half as long again as the first. Eyes separated on the vertex by a distance equal to the length of the three basal joints of the flagellum. Head and thorax very finely and closely punctured, thorax short; median segment a little shorter than the mesonotum, twice as broad as long, very broadly rounded posteriorly the dorsal surface rather finely and irregularly longitudinally striate, the posterior slope vertical and transversely striated, the sides of the segment finely obliquely striated. Abdomen very finely and closely punctured, the apical margin of the segments almost smooth. Tarsi rather slender, anterior femora strongly emarginate at the base. Radial cell short, obliquely and broadly truncate at the apex. Fourth abscissa of the radius no longer than the third, and about equal to the first, the second very short; third cubital cell broad, not produced on the cubitus, scarcely more than half as long on the cubitus as the second; first recurrent nervure received very near the base of the second cubital cell, second close to the middle. Tegulæ brown.

Hab. Pusa, Bihar, (*G. R. Dutt*), March.

This belongs to the group of the Spanish *T. brevipennis* Mercet, but is very much smaller, the median segment is shorter, the radial cell shorter and more broadly truncate, and the third cubital cell much broader on the radius and less produced on the cubitus. *T. instructus* Nurse (= *T. striolatus* Cam. 1908, nec. 1903) belongs to the same group, but has the median segment longer.

Tachysphex latissimus sp. n.

♀. Nigra, mandibulis, clypeo, scapo, tegulis, scutello, segmento mediano, segmento abdominali primo, segmento sexto, segmentis ventralibus in medio infuscatis, mesosterno, pedibusque ferrugineis; segmentis dorsalibus 1—5 apice late pallide decoloratis; alis hyalinis, venis testaceis.

♂. Feminæ similis; scutello, segmento mediano, mesosternoque nigris.

Long. ♀, 10 mm.; ♂, 7 mm.

♀. Clypeus at the base and front covered with silver pubescence, the apical margin of the clypeus transverse, shining and broadly depressed. Second and third joints of the flagellum subequal, each more than twice as long as the first. Eyes separated on the vertex by a distance equal to the combined length of the second and third joints of the flagellum. Head and thorax opaque, minutely and very closely punctured; median segment finely granulate,

with a depressed median line. Fore tarsi with a long comb, the basal joint with eight spines, the two apical spines feebly spatulate. Abdomen almost smooth, the punctures microscopic; the apical margins of the dorsal segments shallowly and very broadly depressed. Pygidial area shining, with scattered minute punctures, elongate triangular, the margins not strongly raised. Pubescence of the thorax greyish and rather dense, especially on the median segment. Radial cell broadly obliquely truncate at the apex, not reaching nearly so far as the apex of the third cubital cell; first and second abscissæ of the radius subequal, the third distinctly shorter, the fourth as long as the second and third combined; the recurrent nervures separated on the cubitus by a distance almost as great as the length of the second abscissa of the radius.

♂. Femora very distinctly excised near the base; eighth ventral segment shallowly emarginate at the apex, with a short spine on each side at the apical angles; second abscissa of the radius shorter than the third.

Hab. Pusa, Bihar, (*G. R. Dutt*), May.

The male has very fine and sparse pubescence on the abdomen, especially on the sides, but not forming apical fasciæ. The eyes in this species are very far apart on the vertex, as in *gujaraticus* Nurse, but the pubescence of the thorax and median segment is much shorter in that species and the sculpture of the median segment quite different.

Tachytes proxima Nurse.

Tachytes proxima Nurse. Ann. & Mag. Nat. Hist. (7) XI, p. 514, 1903. ♀.

According to my determination this beautiful species occurs at Pusa and Chapra. It seems to differ from *T. taprobanæ* Cam. only in the narrow and elongate pygidial area, which in *taprobanæ* is broadly triangular. The male has the golden pile much paler than in the female; the seventh dorsal segment is narrowly rounded at the apex; the seventh ventral segment semicircularly emarginate at the apex, leaving a stout tooth on each side at the apical angles.

Tachytes brevipennis Cam.

Tachytes brevipennis Cam. Ann. & Mag. Nat. Hist. (7) V, p. 22, 1900. ♀.

In fresh specimens the pubescence on the pygidium is bright golden; not mixed with black, as in Cameron's description and in a specimen marked by him as type in the British Museum, which is evidently discoloured.

Hab. Chapra, Bihar (*Mackenzie*).

Tachytes comberi sp. n.

♀. Nigra ; clypeo, fronte, pedibusque argento-sericeis ; segmentis dorsalibus 1—4 apice utrinque fascia albosericea ; area pygidiali rugosa, haud sericea ; tarsis articulo apicali basi fusco-ferrugineo ; spinis tarsorum brunneis ; alis hyalinis, venis ferrugineis ; tegulis pallidis.

♂. Feminæ similis ; segmento dorsali septimo albosericeo.

Long. ♀, 19 mm. ; ♂, 13 mm.

♀. Clypeus very broadly rounded at the apex, with a small tubercle on each side a little nearer to the middle than to the base of the mandibles, the apical margin narrowly depressed and opaque, the base very finely and closely punctured. Second joint of the flagellum distinctly longer than the third ; eyes separated on the vertex by a distance equal to the combined length of the first and second joints of the flagellum. Anterior ocellus round, the space about the posterior ocelli shallowly depressed ; vertex opaque, almost smooth. Thorax very closely and minutely punctured, still more finely on the pleuræ than on the dorsulum ; median segment minutely granulate on the dorsal surface ; the posterior slope transversely striated, with a deep median sulcus which extends on to the apex of the dorsal surface ; the sides of the segment closely and finely vertically striated. Abdomen smooth and shining, the apical margins of the segments broadly and shallowly depressed ; pygidial area elongate triangular, very narrowly rounded at the apex, strongly rugose at the base, more finely at the apex, without pubescence. Basal joint of the fore tarsi with seven stout spines ; the longer spur of the hind tibiæ fully as long as the basal joint of the hind tarsus. Radial cell narrowly rounded at the apex ; second and third abscissæ of the radius subequal, shorter than the first ; the distance between the recurrent nervures on the cubitus less than the second abscissa of the radius.

♂. The minute tubercles on the apical margin of the clypeus obsolete ; seventh dorsal segment clothed with silver pubescence, rather broadly rounded at the apex ; eighth ventral segment with a tooth on each side at the apical margin, depressed and emarginate between the teeth. Apical joint of the flagellum broadly obliquely truncate at the apex.

Hab. Karachi, (*E. Comber*), October.

This fine species is remarkable for the bare pygidial area of the female. In structure it is somewhat allied to the European *T. etrusca*, but differs much in colour, and in the antennæ of the male.

Tachytes celsissimus sp. n.

♀. Nigra ; pallide flavidulo-pubescente ; segmentis dorsalibus 1—4 apice albido-pubescentibus ; pygidio aureo-setoso ; unguiculis spinisque ferrugineis ; alis pallide flavo-hyalinis, venis testaceis.

♂. Feminæ similis ; thorace fulvo-piloso ; pygidio argenteo-pubescente.

Long. ♀, ♂, 14 mm.

♀. Clypeus closely and minutely punctured, with a deflexed triangular space at the apex. Second joint of the flagellum distinctly longer than the third ; eyes separated on the vertex by a distance about equal to the length of the second joint of the flagellum. Front slightly convex below the anterior ocellus, and covered with pale yellowish pubescence which extends on to the clypeus. Thorax closely and minutely punctured and densely clothed with pale yellowish pubescence, which also covers the median segment ; the latter short and broad, much shorter than the mesonotum, with a fovea at the apex, which is continued as a median sulcus on the posterior slope. Abdomen subopaque, very finely aciculate ; the ventral surface shining, smooth at the base of the segments, minutely punctured at the apex. Pygidial area very broad, narrowly rounded at the apex. Basal joint of the anterior tarsi with five rather feeble spines ; the longer spine of the hind tibiæ a little shorter than the basal joint of the hind tarsi. Radial cell narrowly rounded at the apex ; second abscissa of the radius shorter than the third ; distance between the recurrent nervures on the cubitus a little greater than the second abscissa of the radius, but less than the third.

♂. Similar to the female ; but the pubescence on the thorax is bright fulvous, the middle joints of the flagellum are very feebly arcuate beneath, the seventh dorsal segment very broad, broadly subtruncate at the apex, and clothed with silver pubescence ; eighth ventral segment broad, very shallowly subemarginate at the apex, without spines.

Hab. Shillong, Khasi Hills, 6,000 feet, (*Turner*), September.

This resembles a small specimen of *T. sinensis* Sm., but has the pygidial area much broader, the median segment shorter, one spine less on the basal joint of the fore tarsi, and the eyes further apart on the vertex in both sexes. The seventh dorsal segment of the male is much broader at the apex than in *sinensis*, closely resembling that of *T. saundersi* Bingh., but that species has the eighth ventral segment more deeply emarginate and with strong teeth at the apical angles, and is different in the colour of the pubescence and the lesser

distance between the eyes on the vertex. The species does not agree with any of the species described by Cameron from the Khasi Hills.

Trypoxylon nodosicornis sp. n.

♂. Niger; mandibulis fusco-ferrugineis; femoribus anticis supra, tibiis anticis supra nigrolineatis, femoribusque intermediis extremo apice, ferrugineis; tarsis anticis omnino, intermediisque basi pallide luteis; tegulis testaceis; alis hyalinis, iridescentibus, venis nigris; flagello articulo quinto infra excavato, sexto infra tuberculo magno triangulari.

Long. 9 mm.

♂. Clypeus clothed with silver pubescence, truncate at the apex, with two minute teeth in the middle of the apical margin; eyes separated at the base of the clypeus by a distance equal to the combined length of the scape and the first joint of the flagellum, the distance between the eyes on the vertex slightly greater. Posterior ocelli twice as far from each other as from the eyes, separated from the eyes by a distance scarcely greater than half their own diameter. Front rather strongly convex, with a distinct median depression from the anterior ocellus nearly reaching the base of the antennæ; no carina between the antennæ. Second joint of the flagellum shorter than the first; joints 2—4 broader than long; fifth joint longer, very deeply emarginate beneath; sixth joint with a large triangular tubercle beneath; joints 7—9 a little longer than broad, the three apical joints longer and stout, the apical joint conical, no longer than the penultimate. Opaque, microscopically punctured; the abdomen shining, median segment subopaque, with delicate and very short striæ at the extreme base and a deep median groove from base to apex, with shallow lateral grooves enclosing a basal area, the posterior slope concave. First abdominal segment twice as long as the second, slightly swollen at the apex, the extreme apex a little constricted. Sides of the median segment smooth and shining; a deep fovea on the mesopleuræ.

Hab. Dungagali, Hazara District, 8,000 feet, May, (*T. Bainbrigge Fletcher*).

Easily distinguished by the remarkable antennæ. I do not think that this can be the male of *T. simlaense* Cam., to which it seems most nearly related.

APPENDIX

CONTAINING TWO DESCRIPTIONS

BY

G. R. DUTT, B.A.,

Entomological Assistant, Pusa.

Gorytes ornatus Sm. ♀.

HEAD smooth, shining, almost impunctate, a longitudinal impressed line running from the anterior ocellus to the extremity of the frons, inner orbits of the eyes nearly parallel; clypeus convex, widely emarginate in the middle; antennæ short, inserted just above the base of the clypeus, scape more or less conical. Pro- and meso-thorax very lightly and sparsely punctured, median segment with a medial longitudinal furrow and two lateral convergent light furrows (rather depressions) enclosing a triangular area at the base of the segment, this triangular area and the lateral depressions obliquely striate; a medially transversely striate furrow continued down from the apex of the enclosed area to the apex of the segment. Abdomen almost fusiform, lightly punctured, punctures on the second segment sparse, closer on the third and fourth segments. Legs of moderate length, anterior tarsi ciliated. Black; the clypeus and the face for nearly three-fourths of its length along the inner orbits of the eyes covered with thick white glittering pile, the sides of the median segment and the base of the basal abdominal segment with erect white pubescence; thorax from above and the tarsi ferruginous, the clypeus, face along the inner orbits of the eyes for three-quarters of its length, scape of the antennæ from below, apical half of the anterior and intermediate femora from below and the basal half of the posterior tibiæ from above, two semi-circular marks touching each other at a point in the middle of the apical margin of the basal abdominal segment, a wide bisinuate transverse band on the apical margin of the second segment, apical half of the fifth segment, yellowish white. Wings light fusco-hyaline, radial and cubital cells shaded with fuscous clouds, nervures and tegulæ testaceous.

♂. Similar, differs in having the vertex behind the ocelli, the mandibles and the legs (excepting the posterior pair which are shaded black), ferruginous. There is an entire absence of the semicircular marks on the basal segment.

Hab. Bihar, Pusa (*G. R. Dutt*).

" Chapra (*Mackenzie*).

♀. Length 6 mm. Wing expanse 11 mm.

♂. Slightly smaller.

(♀. Described from a single specimen.)

Solierella turneri n. sp.

Head, thorax, and abdomen very finely and closely punctured, median segment coarsely reticulate, clypeus bearing a strong carina, antennæ short, inserted just above the base of the clypeus, eyes slightly converging towards the vertex; pronotum narrow transverse, scutellum prominent, median segment truncate posteriorly, with a central fovea at the verge of truncation above, the face of the truncation is transversely striated and bears a medial longitudinal furrow; abdomen long, a little longer than the thorax, the basal segment slightly concave, the base of the second and third segments slightly constricted. Black; the clypeus, face, and cheeks posteriorly covered with silvery glittering pile, a medially interrupted transverse band on the posterior margin of the pronotum, the tegulæ excepting a central brownish mark, tubercles, a transverse line on the postscutellum, the intermediate and the posterior tibiæ and tarsi (excepting a few black marks on them), and a mark on the anterior femora and tibiæ, yellow; the anterior tarsi slightly brownish.

Hab. Bihar, Pusa (*G. R. Dutt*).

Length 3·5 mm. Wing expanse 5·5 mm.

(Described from a single specimen which is the type.)

[Very near the European *S. compedita*, Picc., but the sculpture of the median segment is very different.—R.E.T.]

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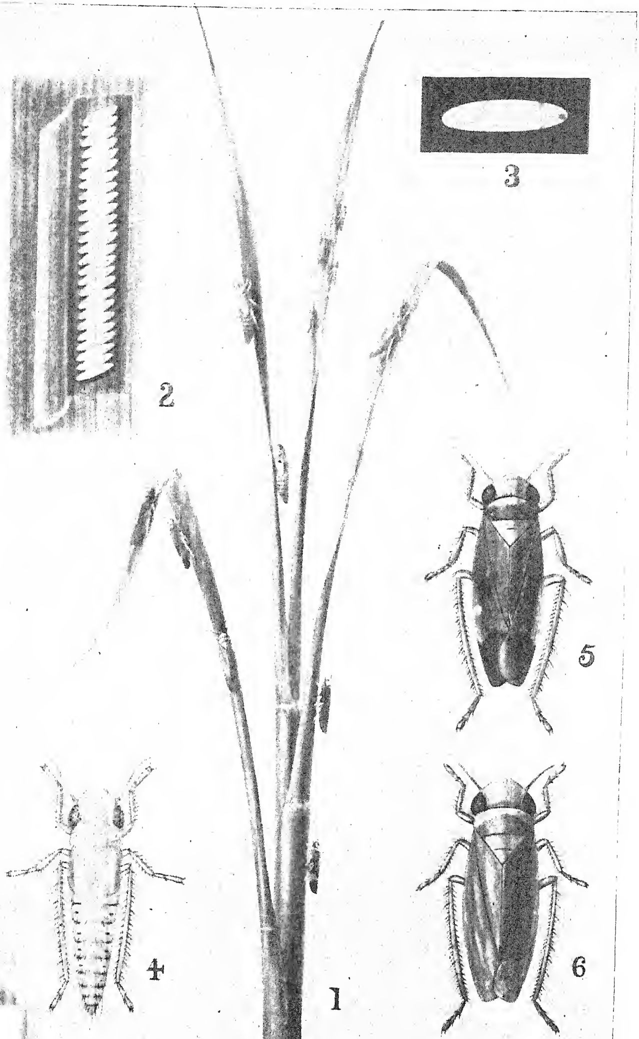

NEPHOTETTIX BIPUNCTATUS.

EXPLANATION OF PLATE XX.

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THE RICE LEAF-HOPPERS (*NEPHOTETTIX BIPUNCTATUS* FABR., AND *NEPHOTETTIX APICALIS* MOTSCH).

BY

C. S. MISRA, B.A.,

First Assistant to the Imperial Entomologist.

[Received for publication on 19th June, 1919.]

Occurrence, damage and area affected.

The rice leaf-hoppers were reported for the first time damaging rice in the Sambhalpur District in the Province of Bihar and Orissa in 1910. But the hoppers appeared late in the season and consequently no notice was taken. During 1913 they again appeared although late in the season and did some damage to the standing crop of rice. The same year they were also reported from Champhai in the Lushai Hills . . . . Mr. J. Hezlett, I.C.S., Superintendent, Lushai Hills, Aijal, wrote on the 4th December, 1913 :—

* * * * * * * * *

"The flat areas under wet rice cultivation are small and are surrounded by miles of jungle. The insect is well known to the Lushais and frequently does some damage, but for the first time this year the damage done by it has become serious."

In the Chhattisgarh Division of the Central Provinces the pests were noticed for the first time in 1913, in which year they appeared late in the season and did some damage to the standing crop of rice. The following year (1914) they appeared early and over a much larger area. The damage was specially great in the Sakti State, and the Mungeli and the Janjgir Tahsils in the Bilaspur District and in Baloda-Bazar and Raipur Tahsils in the Raipur District in the Central Provinces. The damage done by the hoppers was so serious that the Commissioner of the Chhattisgarh Division, Mr. H. M. Laurie, I.C.S., Central Provinces, wrote :—

"I have been touring in the Mungeli Tahsil of the Bilaspur District and I find much complaint of havoc caused in respect to the heavier kinds of rice by the insect '*Mahor*' or '*Maho*' concerning which you have already made some inquiries. The Deputy Commissioner does not think that the damage in the Mungeli Tahsil has in any village exceeded four annas, but I am not

quite sure about this. I am inclined to think that in some villages where '*Mai*' or '*Garhuna*' *dhan* constituted the bulk of the rice sown the damage may have arisen to eight annas or in some cases even more. A loss of four or six annas in this kind of *dhan* will, according to my belief, be found to be a matter of fairly common occurrence even in the Mungeli Tahsil. The damage done in the Janjgir Tahsil is said to be greater than in Mungeli. There is complete unanimity of opinion that the pest is absolutely new in the experience of the Chhattisgarh cultivators. Not even the oldest inhabitant has seen anything like it before . . . . ."

In order to understand the damage done by the hoppers in the Chhattisgarh Division in the Central Provinces one had to visit the worst infested areas. In such places the condition of the cultivators, as well as the cattle, was pitiable. The crop was left standing in the fields and was not harvested. There was not only scarcity of grain but the cattle had not enough straw to eat. By the attack of the hoppers the straw was rendered insipid, and, as such, was not liked by the cattle. Further, with the thick deposition of honey-dew on the rice leaves the straw had become sticky, and smelt mouldy. It was thus feared that if the pests broke out again in the ensuing year (1915), the state of affairs would be very grave indeed. In this connection Mr. D. Clouston, Deputy Director of Agriculture, Southern and Eastern Circles, Central Provinces, wrote on the 16th June, 1915 :—

"It appears to me, however, that in the event of the pest doing as much damage this year as it did last year, it would be highly advisable to consider whether it is not necessary to appoint a larger entomological staff for the pioneer work. Even if the pest should fail to spread beyond the confines of Chhattisgarh, we still have in that division alone nearly 3 million acres of rice. If we allow only 10 per cent of the area being affected, we would still have 300,000 acres to deal with . . . ."

The total area under rice in the Chhattisgarh Division, Central Provinces, is :—

	Acres
Drug District	**679,786**[1]
Raipur District	**1,486.115**
Bilaspur District	**1,149,583**
Total ...	**3,315,484**

Calculating a loss of six annas in the rupee (*vide* the Commissioner's report quoted above) for the badly infested sub-divisions (*Tahsils*) of the Raipur and the Bilaspur districts :—

[1] *Season and Crop Report, C. P. & Berar*, 1915-16.

Bilaspur District.[1]

	Acres		Total
Janjgir	566,326		
Bilaspur	329,167		
Mungeli	144,655		
	1,040,148	...	1,040,148
Raipur District.			
Mahasamund	484,928		
Baloda-Bazar	358,181		
	843,109	...	843,109
	TOTAL	...	1,883,257

the total loss approximates $14\frac{1}{2}$ million rupees on the basis of 548 lb. cleaned rice per acre[2] at Rs. 3-1-0 the whole-sale price of common cleaned rice at Bilaspur (Feb. 15, 1916).[3] This enormous loss represents the destructiveness of the hoppers for one season only and it is not known what would have been the accumulated loss, had they run for a series of years consecutively.

During 1915 the pests appeared late and in small numbers and in consequence no serious damage was done. But previous to their appearance, the small white leaf-hoppers—*Sogata pusana* Dist., *Sogata distincta* Dist. and *Sogata pallescens* Dist.—(Figs. 1, 2 and 3)—appeared in enormous numbers

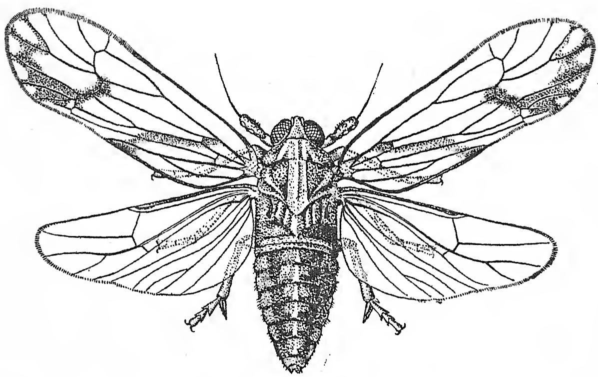


FIG. 1. *Sogata pusana.* (× 20).

[1] *District Gazetteers, Raipur & Bilaspur,* 1907-08.
[2] *District Gazetteer, Drug,* 1907-08.
[3] *Season and Crop Report, Central Provinces & Berar,* 1915-16.

along with the rice grass-hopper (*Hieroglyphus banian*) at the end of July and the beginning of August and it was feared that this time too the rice crop would be damaged seriously. In fact, in most places complaints were made that the *Maho* (*N. bipunctatus* and *N. apicalis*) had appeared and had begun damaging the rice plants. In others, the white leaf-hoppers were actually mistaken for the *Maho* and the measures recommended to check them were adopted against the white leaf-hoppers. No doubt the damage done by the white leaf-hoppers (*Sogata* spp.) was very much akin to the damage done by the *Maho* (local name for the leaf-hoppers *N. bipunctatus* and *N. apicalis*). Both live by sucking the juice of the tender plants and the grain in the ears and both exude a sticky substance, technically known as honey-dew, which, falling on the leaves, leads to the growth of a black fungus *Capnodium* sp. If both the pests are present concurrently, the young plants wither and the infested fields present a blighted appearance. Continuous rain is favourable

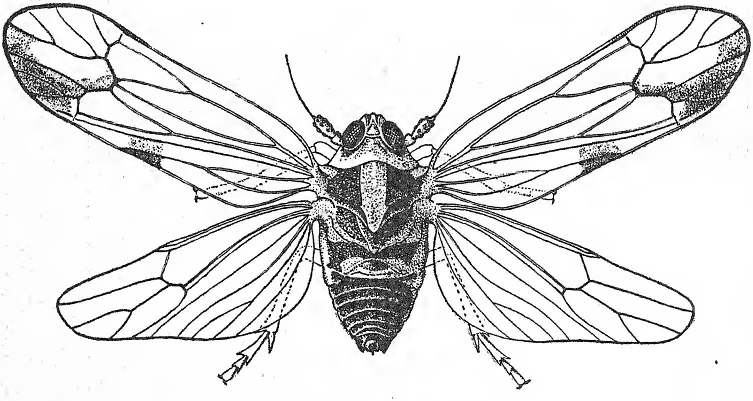


FIG. 2. *Sogata distincta.* (× 24).

to the development of the white leaf-hoppers and not so favourable to the development of the *Maho*, and as there were heavy rains at the end of July and the beginning of August 1915, it was feared that the two pests would again ruin the crop completely. But with the break in the rains in the middle of September, the white leaf-hoppers perished and no more trouble was

experienced. Numbers of young leaf-hoppers were parasitized by a Dryinid, and it was a common sight in the infested fields to see them hopping about from plant to plant with broad, oval, blackish sacs on their abdomen laterally. A week or ten days after, the leaves were seen covered with the whitish hammock-like pupa cases of the Dryinid. Even the few adult Dryinids that had emerged were to be seen flitting about the infested plants. By the third week in September the whitish leaf-hoppers as well as the rice grass-hoppers (*H. banian*) had disappeared and the *Maho* was reported to have appeared in a few villages in the Sakti State in the Bilaspur District. No doubt reports used to come in intimating the appearance of the *Maho* in the various parts

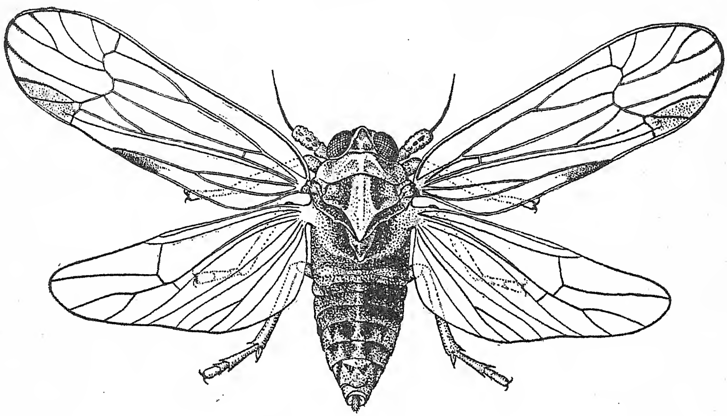


FIG. 3. *Sogata pallescens.* (× 20).

of the division, but on close examination in the third week of October 1915, it was found that, though the leaf-hoppers were there, they were present in small numbers only and could not damage the crop seriously. In many places, the cultivators, apprehending the possible appearance of the leaf-hoppers, had sown their fields with *Harhuna*—early ripening varieties of rice—and by the time the leaf-hoppers appeared by the middle of October 1915, the plants had matured and were past damage. The leaf-hoppers did not appear at all during 1916 and 1917, and no reports of their appearance have been received up to the time of writing this Memoir

Besides the Central Provinces, the hoppers have also been reported bad from Sambhalpur during 1910, 1912, 1914 and present in small numbers only during 1911–1913 and 1915. Just as in the neighbouring district of Bilaspur the damage done by the leaf-hoppers during 1914 was very widespread and serious and in June 1915, when I visited the district in connection with the leaf-hoppers, the cultivators were very apprehensive of any subsequent outbreak of the pests and were willing to adopt any measures that were found effective against them. They have also been reported from Kendrapara in the Cuttack District, and Balasore. The damage in the latter district was also very great and widespread, and Mr. F. M. Howlett, the Pathological Entomologist, who visited the area in 1914, wrote :—

"It was seen that in some fields practically the whole crop was destroyed, the plants withered and discoloured. These seemed to be all late-transplanted, the earlier crops having suffered much less, often hardly at all. A rough estimate gives 25–40 per cent as the average amount of damage in Balasore and its immediate neighbourhood. Jassids (Genus *Nephotettix*) were considered by the cultivators to be responsible for the whole damage. They were present in large numbers and in all stages."

The hoppers have also been reported from Ranchi and Champhai in the Lushai Hills.

The appearance of the infested fields.

The infested fields appear blighted. If the pests appear early when the plants are only two months old, the latter at first turn pale-yellow and soon after wither. If the pests appear late the apical buds of the plants remain somewhat swollen and the ear-heads fail to come out. If, however, the pests appear when the ears have come out and grain is being formed they turn pale-brown and later on russet-brown without any grain in them. The leaves, specially the lower ones, become thickly covered with a layer of honey-dew exuded by the nymphs as well as by the adults. In some places, specially in Janjgir Tahsil and the Sakti State, complaints were made that the water of the infested fields had turned red and that when such fields were harvested a thick layer of red was found deposited on their surface. I examined this aspect of the hoppers' attack but was unable to find any data to support the belief. It is possible that, when the infested fields were about to be harvested, occasional rain fell and it washed the lateritic nodules in process of disintegration on the *bhata* soils—so common in the Chhattisgarh Division, Central Provinces—and the washings from these accumulated in the low-lying fields below the *bhata* lands. When the water from such fields evaporated, a thin

layer of reddish sediment was naturally deposited on the surface soil of fields. Besides this plausible explanation of the phenomenon witnessed by the local cultivators, I could not offer any. I examined the water of the worst infested fields during 1915 at Janjgir but could find no connection between the presence of honey-dew on the leaves and the reddish discoloration of the infested fields.

LIFE-HISTORY.

In the Chhattisgarh Division of the Central Provinces the pests are called '*Maho*' or '*Mahor,*' but the former term is generally more in use. Prior to 1913 in the Central Provinces and 1910 in Sambhalpur in the Province of Bihar and Orissa, nothing was known about the hoppers. Till then they were known as the "Green-flies" of cities like Calcutta, where they swarm in thousands around the electric lamps in the streets as well as the bare lights in houses. It is an instance of an insect which is considered harmless at one time, but suddenly comes into prominence, does considerable damage for a series of years and again sinks into insignificance. The hoppers were very bad in 1914. They did slight damage in 1910, 1913 and 1915, but did not appear in 1916–17 and the current year. The causes which have contributed to their disappearance directly or indirectly are not well understood up to this day. That this has been brought about by the agency of the parasites is out of the question, as very few effective parasites were found either on the eggs, the nymphs or the adults.

After the winter is over, the hoppers begin to breed in succulent grasses in tank beds and such other places which contain green grasses. Until the beginning of June they remain breeding in succulent grasses as well as nursery seed-beds. From these they move on to the tender rice seedlings in the beginning of July and, if the rains are heavy and continuous, the majority of them are washed away and there are no reports about the *Maho* from any part of the ordinarily infested areas. If, however, the rains are not very heavy in July and August and there is a spell of fair weather, then the hoppers breed very fast and overrun large tracts of rice lands. At least some such state of affairs could be deduced from close observations made in the affected areas during 1914–1916. In some years they appear late in October or early in November and very little damage is done, as by that time the early-ripening varieties of rice are ready to be harvested. If, however, any damage is done, it is to the late-ripening transplanted varieties of rice. When such is the case, vast hordes of hoppers are destroyed annually in the small lamps that are lit up in the towns and villages on the *Dewali* day—a Hindu festival which occurs yearly in the end of October or the beginning of November. The

adult hibernates in grasses, but only in small numbers. Of the two species of hoppers, *Nephotettix bipunctatus* Fabr., and *Nephotettix apicalis* Motsch., commonly known as the *Maho*, the former preponderates over the latter, as was evident from counts made in the fields at Janjgir (Bilaspur), Sindewahi (Chanda), and Pusa (Bihar) during 1914 and 1915.

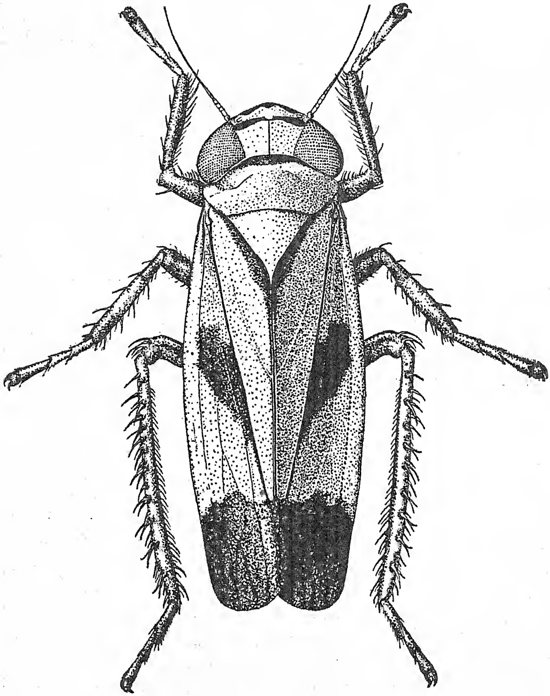


FIG. 4. *Nephotettix apicalis.* (× 24).

The hoppere are small, greenish insects which jump about from plant to plant and suck the juice. The adults come to light freely and are very active.

The young ones do not fly so actively as the adults and are not attracted to light. The males have two prominent black spots on their bodies, the females have no such markings. In order to be able to distinguish between the two species, both of which are designated as the *Maho* by the local cultivators, the following descriptions of the two species from the *Fauna of British India*, Vol. IV, pp. 359–362, will enable one to distinguish one species from the other.

Nephotettix bipunctatus Fabr.

(Plate XX, fig. 5.)

Yellowish-green, shining, smooth face (except the lateral margins), and a spot on each side of clypeus black; tegmina with a spot before the middle and the apical two-fifths black; lateral spots to sternum and abdomen black. The female is usually without the discal black spot to the tegmina and with the face as just described for the varietal male.

Nephotettix apicalis Motsch.

(Text fig. 4.)

Yellowish-virescent, smooth, shining face, anterior sub-impressed line on vertex between anterior margins of eyes, anterior margin of pronotum, scutellar and commisural margins of clavus, a spot before the middle extending to the claval suture and there acutely produced hindward, the apical third to tegmina, sternum, abdomen, greater part of the femora, anterior tibiæ and tarsi black; the posterior tibiæ at the bases of the spinules spotted with black; ventral incissure flavescent.

Closely allied to *N. bipunctatus* Fabr., but differs in having the head shorter and more obtuse, anteriorly obtusely rounded and by the marking of same. Head as broad as pronotum but somewhat shorter, vertex a little longer in the middle than at the eyes, scarcely twice as broad between eyes as long, anteriorly within the margin transversely impressed.

In plain language, the females in both the species are unspotted. They are pale-green in colour, with a strong, brownish ovipositor with which they lacerate the tissues of the plant and deposit the eggs. The males, in both the species, are black; one has two black prominent spots on the wings, in the other there are two oblique black lines. There is very little difference between the females of the two species. In fact, the colour differences are so slight that none but a trained man could differentiate between the two species. The adults, both males and females, remain on the lower surface of leaves mostly near the midribs sucking the juice during the hottest part of the day. At dusk they become active and fly from plant to plant. While feeding they exude a sticky liquid, called honey-dew, which, falling on the leaves below, makes them very sticky. In the worst infested localities from 37 to as many as 127, and even 167 adults and nymphs have been counted feeding on a single leaf of a plant. The drain caused by such a horde of insects becomes apparent very soon as the plant withers and dies prematurely.

THE EGGS.

The female (Plate XX, fig. 6) lacerates the tissues of the bases of sheathing leaves with her strong ovipositor and deposits the eggs in a mass in a line touching each other closely. The majority of the eggs were found laid at the base of sheathing leaves although in the worst-infested fields eggs were also found laid in the edges and midribs of leaves. At the bases of sheathing leaves, the place where the eggs are laid swells up and turns slightly pale-yellow. On the same leaf there may be as many as six to seven egg clusters but in the majority of cases the number varies from two to four. The effect of prolific oviposition is that the sap which should have gone up for the development of the leaves is cut off, and in consequence they turn pale-yellow and appear sickly.

The female begins to lay eggs the tenth day after reaching maturity. She is easily distinguished from the male by the absence of black spots on the wings and by the presence of a strong ovipositor (Plate XX, fig. 6). When about to lay eggs she moves about the leaves and having selected the place—which, in the majority of cases, is the base of sheathing leaves to stems—she settles down, stretches out the legs, and with the ovipositor makes a longitudinal slit separating the upper from the lower epidermis, and inserts the eggs. In one particular instance on 21st October, 1916, a female was observed to lay 34 eggs within an hour. After the eggs are laid she shakes the wings briskly and moves away. Externally there is no sign of the eggs, except that there is some swelling on the spot if looked at closely. In some varieties of paddy with deep green leaves, the places of oviposition turn pale-yellow. The length of the slit containing the eggs varies from 6–9 mm. In some cases the eggs were found laid on both the edges of the leaves.

The number of eggs laid by a female varies from 24 to 34, though in some egg-masses the number of eggs laid was as low as 18 and as high as 37.

1st Egg mass	22	
2nd ,, ,, ...	24	
3rd ,, ,, ...	18	
4th ,, ,, ...	24	
5th ,, ,, ...	20	
6th ,, ,, ...	21	
7th ,, ,, ...	24	
8th ,, ,, ...	35	
9th ,, ,, ...	37	Average No. 24.

Each egg is 1·35 mm. long and about 0·30 mm. broad in the middle. It is smooth, rounded at both ends. Each egg touches the next one laterally and is somewhat rounded in the middle. When laid, the colour of the eggs is pale-yellow. Later on they turn pale-yellow with two bright pinkish spots

representing the eyes of the nymph within. As the nymph develops within, the two spots turn deep maroon in colour (Plate XX, figs. 2 and 3).

When the nymph emerges, a slit opens at the apex represented by two deep maroon coloured specks and the head is thrust out. The nymph then moves from side to side until it is clear of the egg-shell. It is then slimy and remains enveloped in a thin membrane, which on exposure ruptures, and the nymph is able to come out leaving the amnion attached to the apex of the empty egg-shell as a thin, crumpled pellicle. In some cases the crumpled pellicle lies on the leaf close by the opening in the egg-shell. At times when nymphs are emerging in numbers they may be seen standing bolt upright against the leaf surface. They are able to remain in this position as their bodies are moist whilst enveloped in the thin membrane containing them.

The eggs are parasitized by a small pale-yellow Chalcidid. The parasitized eggs turn black and the Chalcidid emerges by making a small, clean circular hole on the egg. After the emergence of the parasites the empty egg-shells appear deep fuscous brown with their apices black. But the number of parasitized eggs is not very large, and this parasite is not effective in checking the increase of the hoppers.

THE NYMPHS.

The nymph on coming out of the egg-shell is active and after a few seconds only begins to move about on the leaf (Plate XX, fig. 4). As soon as it comes upon a succulent spot it begins sucking the juice and exuding the honey-dew which falls thickly on the lower leaves. It is on account of this that the leaves become sticky and are covered with a black fungus. Locally the cultivators explained the discoloration of water of the infested fields by the exudation of honey-dew, but on close observation there appeared to be no connection between the discoloration of water of the infested fields and the falling of the honey-dew. The discoloration of the infested fields is probably due to the accumulation of washings from the *bhata* soils which are covered with lateritic nodules in process of slow disintegration.

The nymphs with the adults drain the sap of the plants which in consequence become pale and subsequently wither away without putting forth ears. If a heavily infested leaf be held up to the light it will be found to contain a large number of tiny transparent holes representing the punctures made by the nymphs as well as the adult hoppers with their strong beaks. The nymphs do not fly, but when disturbed, jump from plant to plant. They remain feeding below leaves during the hottest part of the day. Unlike the

adults they are not attracted to light. In the case of the worst infested fields as many as 167 adults and nymphs were found on a single leaf.

The nymph after coming out of the egg-shell is pale-yellow with prominent deep maroon eyes, the thorax and the abdomen are dorso-laterally suffused with faint ochreous. The legs are whitish. Antennæ dull white (Plate XX, fig. 4). The nymphs of the early instars remain feeding and exuding the honey-dew on the lower surface of leaves. When about to moult, the legs are thrown wide apart and a slit opens dorso-frontally and the nymph comes out. The rostrum is embedded so firmly in the tissues of the leaf that if the exuvium be removed with a teaser a part of the body breaks off leaving the head with the sheaths to rostral setæ embedded in the tissues of the leaf. When full-fed the nymph becomes very active and may then be seen moving actively up and down the leaves. With the least disturbance they jump off from plant to plant and remain feeding quietly on the lower surface of leaves during the hottest part of the day. They are then 4·38 mm. long, 1·24 mm. broad, the head is pointed anteriorly; general colour pale green with prominent maroon coloured eyes. The apex of the tegminal pads reaches the middle of the third abdominal segment dorsally. Anterior and intermediate tibiæ spined lightly, the posterior tibia spined thickly. Abdomen broad at base, tapering posteriorly. The first abdominal segment has no spines on it dorsally. There is a series of deep, brown spots situated dorso-transversely on the middle of the second to the seventh abdominal segments, followed by a series of four deep ochraceous-brown setæ inclined posteriorly on the second to the fifth abdominal segments. On the sixth and the seventh abdominal segments there are six such setæ dorsally, on the eighth abdominal segment seven, and on the anal end there are only four such setæ.

The nymphs before maturing into adults pass through five moults.

Eggs laid	Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Fifth moult
3. IX. 16	7. IX. 16	11. IX. 16	14. IX. 16	16. IX. 16	18. IX. 16	20. IX. 16 Adult emerged
21. X. 16	25. X. 16	28. X. 16	31. X. 16	2. XI. 16	6-8. XI. 16	13-15-XI. 16 Adult emerged

When about to moult the nymph becomes stationary on the leaf, the legs are thrown wide apart and it remains quiet on the spot when a slit opens dorso-longitudinally. The head with the antennæ comes out first, the body is then jerked slowly from side to side until the nymph is completely out of the exuvium, which remains attached to the leaf. The nymph remains

aerating on the spot close to the exuvium for a few minutes, or moves immediately in search of a suitable spot to feed. At the time of moulting the rostrum is so firmly embedded in the tissues of the leaves or the stems, that if the exuvia are lifted with a teaser the rostral setæ break away and remain in the leaf-tissues. From the eggs laid on the 21st October, 1916, an adult male emerged on the 13th November, and an adult female emerged on the 15th of the same month.

The Adult.

After passing through five moults the adults appear on the leaves and are then represented by two distinct species. The characteristic differences between the two species have been already pointed out on page 215. Of the two species, *Nephotettix bipunctatus* was the most predominant, but in habits and other respects there is no appreciable difference between the two species. The observations made and facts regarding life-history recorded in this memoir relate exclusively to *Nephotettix bipunctatus* which was found to be the predominant species in the worst infested areas of the Central Provinces during 1914 and 1915. The adults of both the species suck the juice of the leaves which wither in consequence and the plants in the infested fields appear pale, sickly and wither away prematurely without putting forth ears. The adults exude honey-dew in small, clear drops which accumulate on the lower leaves and it is on such leaves that the black fungus grows most luxuriantly. The adults of both species exhibit a strong predilection for light and it is for this reason that thousands of them are attracted to small lights (locally known as *chirags*) put out on the *Devali* day, a Hindu festival which comes off towards the end of October, or the beginning of November every year. Only a few adults survive the winter and these remain hidden in small, succulent grasses or rice stubbles growing either in damp places or in beds of shallow ponds which are very common in the affected districts of Raipur, Bilaspur and Drug in the Central Provinces and Sambhalpur in Bihar and Orissa. As soon as the winter is over they begin to breed in grasses and stubbles of plants and remain there until rice seedlings are available in June and July. Thereafter their development depends very much upon the rainfall. If it is heavy, as is usually the case in the affected districts, the majority of the adults perish and only a small proportion is left to breed either in grasses or the rice seedlings. If, however, there is a long break in the rains in July–August, the hoppers develop fast and overrun the rice crop. The female begins to lay eggs nine to ten days after reaching the adult stage. Though the number of cycles throughout the year has not been worked out, yet from observations made in the infested districts and other data available, it is presumed that there are

not more than four to five broods throughout the year. But from economic considerations, the third brood seems to be the most important, and if at the time the adults of this brood are breeding in grasses the climatic conditions become favourable, rapid development takes place and the crop is affected seriously, and to me it appears reasonable that the preventive measures should be adopted vigorously at this time. The co-operation of the *malguzars* as well as the landholders and the cultivators should be secured at this time, and I am sure, the results would yield satisfactory results.

LIFE-CYCLE.

In the latter part of the year, especially September and October, a complete life-cycle occupies from 17 to 25 days thus :—

Eggs laid	Eggs hatched	Adults emerged	Life-cycle in days
3. IX. 16	7. IX. 16	20. IX. 16	17
19-20. IX. 16	24-26. IX. 16	7-13. X. 16	18-23
19-20. IX. 16	24. IX. 16	7-13. X. 16	18-23
21. X. 16	25. X. 16	13-15. XI. 16	23-25

The egg stage lasts from 4 to 6 days, and the nymphal stage from 13 to 21 days. The adult female after reaching maturity begins laying eggs on the 9th or the 10th day. In a specific case kept under observation it was found that a female which matured on 12th October, 1916, began laying eggs on 21st October. Thereafter she survived for two days more and then died. This refers to a case under observation in a breeding cage and it is presumed that similar conditions prevail in nature also.

From the beginning of July 1915 until the middle of November 1916, grass lands, field embankments, tank bunds, river sides, etc., were bagged and examined and light traps were put up from time to time to ascertain the presence of the *Maho* and the results were as follows :—

July 1915—

,,	2nd	Light trap	Many adult *Mahos*[1] at light.
,,	14th	Light trap	Many adult *Mahos* at light.
,,	20th	Examination of rice seedlings.	Adults on rice seedlings, majority being males.
,,	27th	Aladdin light (500 candle power).	Many adults came to light.

[1] By the term 'Maho' so frequently referred to hereafter both the species *Nephotettix bipunctatus* and *Nephotettix apicalis* are meant.

August 1915—			
„ 9th	Light trap	*Mahos* especially abundant at light ♂♂ more than ♀♀.	There was rain with cloudy weather.
„ 11th	Light trap	*Mahos* especially abundant.	
October 1915—			
„ 7th	Light trap	Many *Mahos* at light.	
„ 29th	Meduse lamp	62 *Mahos* in the trap.	
November 1915—			
„ 3rd	Grasses bagged	22 ♂♂, 14 ♀♀ *Mahos*.	
„ 18th	Examination of Paddy fields.	Eggs of *Maho* were found laid in the edges of sheathing leaves.	
„ 30th	Meduse lamp	13 ♂♂, 14 ♀♀ *Maho*.	The lamp was set up in rice-fields which were harvested only recently.
December 1915—			
„ 6th	Meduse lamp	No *Maho* was found.	
„ 9th	Aladdin lamp	No *Maho* at light.	
„ 17th	Aladdin lamp	1 ♀ at light.	
„ 21st	Meduse lamp	No *Maho* at light.	
January 1916—			
„ 12th	Grasses bagged	No *Maho* was found.	A few *Tettigoniella rubromaculata* were found.
„ 22nd	Examination of grasses.	No *Maho* was found.	2 *Thomsoniella albomaculata.* 3 *Clovia bipuncta.* 3 *Thomsoniella porrecta.* Adults of these were found in grasses.
„ 29th	Grasses bagged	No *Maho* was found.	1 *Thomsoniella albomaculata.* 1 *Athysanus fusconervosus.* 1 *Oliarus*, sp. 3 *Tettigoniella*, sp. 1 Jassid. Adults of these were found in grasses.
February 1916—			
„ 5th	Grasses bagged, (especially Dub grass *Cynodon dactylon*).	No *Maho* was found.	1 *Tettigoniella spectra.* 2 *Thomsoniella albomaculata.* 2 *Athysanus fusconervosus.* These were found in grasses in the adult stages.
„ 12th	Grasses bagged	No *Maho* was found.	The adults of the following were however found : 2 *Clovia bipuncta.* 1 *Thomsoniella albomaculata.* 2 *Athysanus fusconervosus.* 1 *Adult Fulgorid.*
„ 19th	Grasses bagged	No *Maho* was found.	
„ 21st	Aladdin lamp (500 candle power).	Many adult *Mahos* were found on the screen put behind the lamp.	
„ 26th	Green grass bagged (with handnets).	No *Maho* was found.	
March 1916—			
„ 3rd	Grasses bagged	No *Maho* was found, though the following specimens were found : 1 *Pyrilla perpusilla.* 5 *Athysanus fusconervosus.* 2 Jassidæ.	This time waste lands and fields which were last under rice were bagged with handnets.
„ 11th	Meduse lamp	No *Maho* was found.	The lamp was set up on a tank embankment close to the area under rice last season.

March 1916—			
„ 16th	Grasses bagged	No *Maho* was found, though the following were found : 1 *Eublemma*, sp. 2 *Thomsoniella albomaculata*. 1 *Tettigoniella spectra*. 1 Jassid.	
„ 25th	Grasses bagged	No *Maho* was found, the following were, however, found. 7 *Thomsoniella albomaculata*. 2 *Clovia puncta*. 1 *Tettigoniella spectra*. 2 *Tettigoniella*, sp.	
„ 28th	Meduse lamp	No *Maho* was found, though 2 *Thomsoniella albomaculata* were seen in the kerosine film.	The lamp was set up on a tank embankment close to the area under rice last season.
April 1916—			
„ 7th	Meduse lamp	No *Maho* was found.	The lamp was set up in the area under rice last season.
„ 26th	Meduse lamp	No *Maho* was found, though a large number of Jassidæ were found in the film of kerosine in the pan.	Do.
May 1916.			
„ 6th	Grasses bagged	No *Maho* was found, though the following were found: 2 *Athysanus fusconervosus*. 2 *Tettigoniella spectra*. 1 Fulgorid.	Waste, as well as arable lands, were worked with handnets.
„ 13th	Meduse lamp	No *Maho* was found.	The lamp was set up by the side of the Gandak river where long grasses were growing profusely.
„ 20th	Grasses bagged	No *Maho* was found.	
„ 31st	Meduse lamp	No *Maho* was found.	The lamp was set up in waste lands full of grasses.
June 1916—			
„ 17th	Grasses bagged	3 Female *Nephotettix bipunctatus* were found.	
July 1916—			
„ 4th	Meduse lamp	2 ♀♀, 2 ♂♂ *Nephotettix bipunctatus* were found	
„ 24th	Meduse lamp	10 Adult *Nephotettix bipunctatus* and *N. apicalis* were found at light.	
August 1916—			
„ 4th	Meduse lamp	61 Adult *N. bipunctatus* and *N. apicali* re found at light.	
„ 8th	Meduse lamp	... ...	Heavy rain at night.
„ 9th	Meduse lamp	Only 17 adult *N. bipunctatus* and *N. apicalis* were found.	
September 1916—			
„ 5th	Meduse lamp	97 ♂♂, 104 ♀♀ of *N. bipunctatus* and *N. apicalis* were found.	
15th	Meduse lamp	34 ♀♀, 44 ♂♂ of *Maho* (both the species) were found.	

October 1916—			
,, 13th	Meduse lamp	96 ♀♀, 76 ♂♂ *Mahos* (both the species) were found.	
November 1918—			
,, 3rd	Meduse lamp	16 ♀♀, 20 ♂♂ *Mahos* of both the species were found.	
,, 13th	Meduse lamp	1 ♀, 1 ♂ *Mahos* were found.	The lamp was set in rice area.
,, 17th	Meduse lamp	4 ♀♀, 10 ♂♂ *Mahos* of both the species were found.	The lamp was set in the centre of a large rice area.

The above is a record for sixteen and a half months at Pusa where the climatic and agricultural conditions are different from those prevailing in the rice tracts of the Central Provinces. Had similar observations been available from the above tract it would have been found that the adult hibernates during the winter, that it has a strong predilection for powerful light and that it begins to appear in some numbers from the latter part of June. Steady development seems to take place from the beginning of September and to last until the end of October, and this synchronizes with the development of late or transplanted varieties of paddy. The last two outbreaks bear this out. At both the outbreaks, the greatest amount of damage was done during September–October. Heavy and continuous rain seemed to exercise a prejudicial effect on the development of the hoppers. If the adults and nymphs are not actually washed off in numbers by the rain, their development is restricted considerably and little or no damage is done, as has been the case during the past three years 1916–1918. But this is a factor which cannot be depended upon to check the pest. All that can be done is to adopt preventive measures as early as possible so as to prevent the pests from laying a heavy toll on the agricultural produce as they did during 1914 and 1915.

Distribution of the pests.

Distant has recorded the two species[1] in the *Fauna of India* volumes (Rhynchota, Vol. IV, pp. 359-362) from Calcutta, Pusa, Ranchi, Saraghat, Dacca, Ceylon, Borneo, Sumatra, Philippines, East Africa, Natal and Durban. Dr. Matsumura has recorded *Nephotettix apicalis* to occur in China, Japan, Malay and Europe (*Die Schädlichen und Nutzlichen Insekten vom Zuckerrohr Formosas* 1910, p. 21).

[1] From an economic point of view the two species *Nephotettix bipunctatus* and *Nephotettix apicalis* have been considered together as in development and habits they are much the same.

In the Pusa collection specimens are from :—

Bihar and Orissa	...	Pusa, Balasore, Chhapra, Kankey Farm (Ranchi), Sambhalpur.
Bengal	...	Calcutta, Dacca, Chaumahani.
Central Provinces	...	Raipur District, Sakti, Janjgir (Bilaspur District), Drug District, Sindewahi (Chanda District).
South India	...	Coimbatore, Penukonda, Hagari. Throughout the Plains generally.
Assam	...	Aijal-Champhai (Lushai Hills).

The greatest damage was done in parts of the Central Provinces and Bihar and Orissa. In the Central Provinces, Bilaspur District and some parts of the Raipur District were the worst affected tracts. In Bihar and Orissa considerable damage was done in the Balasore and Cuttack districts. In the Sambhalpur District, the pest was reported for the first time in 1910. Subsequently a report was received from the Superintendent, Lushai Hills, in 1913 that one of the hoppers *Nephotettix apicalis* had damaged the rice crop considerably. From no other part of the country have the pests been reported to have damaged the rice crop to any serious extent. If, however, careful and continued observations are made in the rice-growing tracts, the hoppers will be found to be present though only in small numbers.

Alternative foodplants.

Hitherto the hoppers have been known to affect the paddy plants only, though they are also found in a number of succulent grasses growing in the beds of rivers, nallahs, tank beds and low-lying places. In February 1915 when I visited Sakti State, Bilaspur District, only a few adults were found by me in the long grasses growing in dry beds of ponds and tender rice-plants growing from stubbles of the previous crop. Besides these, the hoppers have not been observed up to this time, infesting or feeding in numbers on any other crop, though it appears probable that in cases of future serious outbreaks they might affect the millets as well. In the Central Provinces they have been found on *Kodon* (*Setaria italica*) and a number of grasses though in very small numbers.

Varieties of paddy affected.

The early ripening varieties *Harhuna* and *Parewa* do not suffer so much as the *Gurmatias*[1] late ripening varieties. The grain in the ears, as well as the leaves of the former varieties, become too tough and matured to attract the hoppers which appear late in the season. It was for this reason that little

[1] Local names of varieties of rice in the Chhatisgarh Division, Central Provinces.

or no damage was done to the early ripening varieties in 1915, as the pests appeared late in numbers. Such varieties are usually sown early and ripen by the middle of October and are then past damage. The late varieties, which are mostly transplanted and, wherever possible, irrigated, remain green and succulent and offer an attractive breeding place for the hoppers. During years of serious infestation an inquiry was begun to find the degree of immunity enjoyed by the local varieties, as it was then thought expedient to recommend extension of an early ripening variety or varieties to escape the loss caused by the hoppers. In fact, in certain parts of the Bilaspur District in the Central Provinces, some of the intelligent cultivators, fearing probable loss of their crop by the hoppers, had put down a greater portion of the acreage cultivated by them under early ripening varieties, which, though coarse, find an easy sale in the local markets in the district. But as the hoppers have not appeared for the last three years, the inquiry has not advanced much further.

From an extensive examination of the affected areas it was also noticed that varieties of paddy growing in *Gehunras*[1] lands were more infested by the hoppers than the same varieties growing in *Matasi*[2] and *Bhata*[3] lands, and the explanation given by me then seems to hold good even now. It was then pointed out by me thus (Report on Investigations regarding the "Maho" *Nephotettix bipunctatus* and *N. apicalis* in the Central Provinces—October 1915, C. S. Misra) :—

"The reason for the preponderance of the pest in one kind of soil than the other is, according to my ideas, explained by the fact that, the *Gehunras* lands being enriched with the washings from the village, produce more succulent plants than those growing in *Matasi* and *Bhata* lands. The plants in the *Gehunras* lands were beautiful deep pale-green, those in the *Bhata* lands being pale-yellow. The ears too of plants in *Gehunras* fields were more filled with grain than those of the *Bhata* lands. Thus, finding the plants in *Gehunras* lands to be more succulent than those in the *Bhata* lands, the pests concentrated themselves in such areas in large numbers. Besides this, the feeding habits of the pests warrant some such conclusion. It being a sucking insect prefers to remain on green, succulent plants than on pale-yellow, prematurely ripening plants. This conclusion I could arrive at after examining a number of fields at Janjgir (Bilaspur District, Central Provinces) sown with *Harhun* and *Gurmatia* varieties of rice in *Gehunras*, *Matasi* and *Bhata* lands."

[1] Lands adjoining villages which are manured from washings from such villages and droppings of cattle which graze therein.

[2] Clay-loam soils.

[3] High-lying lands with calcareous nodules in them.

Local names of the pests.

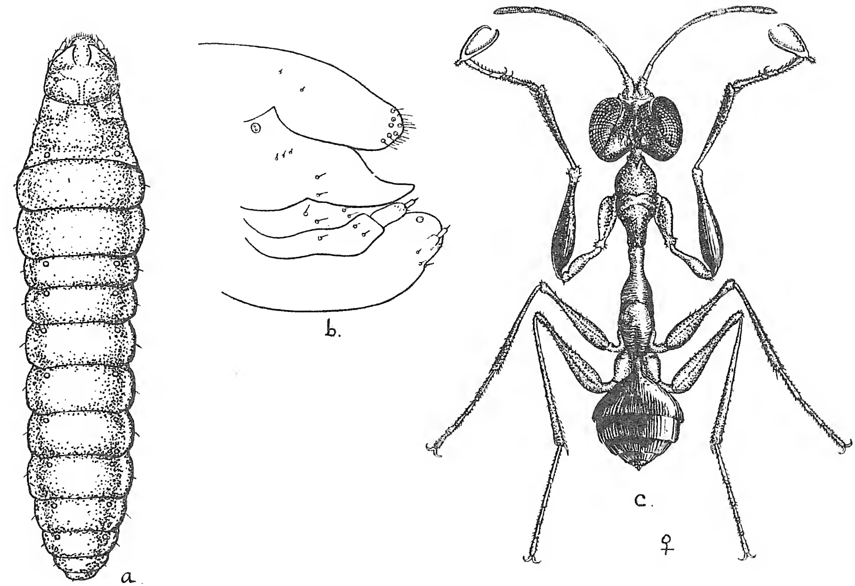
In the Raipur and the Bilaspur districts of the Central Provinces the pests are known as *Mahor* or *Maho*, most commonly the latter. They are so called because they cause the blight of the paddy crop. In the adjoining Orya District of Sambhalpur, they are known as *Daoni*, *Ghunghutti* or *Dhana*. The Lushais call them the *Kumthu*. In the Balasore District (Bihar & Orissa) the pests are known as *Jhatka*. Elsewhere the local names of the two hoppers are not known.

Other Insects which either precede or occur concurrently with the hoppers.

Prior to the appearance of the leaf-hoppers, a number of other insects are found in numbers on the paddy plants. Of these *Heiroglyphus banian* Fb., locally known as the *Phapha*, and three species of the Delphacid leaf-hoppers, *Sogata pusana* Dist., *Sogata distincta* Dist., and *Sogata pallescens* Dist. (Figs. 1, 2 and 3), are the most important. In fact the three Delphacid leaf-hoppers preceded the *Maho* in the Chhattisgarh Division, Central Provinces and appeared by the end of July 1915 when they were mistaken for the *Maho*. The damage brought about by them is very much like the *Maho*, but they are dirty-white in colour and *are not attracted to light*. In fact, they appeared in such large numbers that it was feared that the paddy crop would be damaged seriously, and the climatic conditions prevailing at the time of their appearance favoured this view. Damp moist weather seemed to favour their development whilst a break in the rains seemed to affect them prejudicially. With the break in the rains and the continuance of hot sunny days the Delphacid leaf-hoppers perished and were not heard of again. The work of destruction was to some extent hastened by the timely appearance of the Dryinid parasite (Plate XXI, fig. *c*).

At the end of September 1915 innumerable Delphacid hopper nymphs with chestnut-brown to blackish bags of the Dryinid parasite were seen protruding from the anal or metapleural region laterally (Fig. 5). With the presence of these bags, the nymphs became sluggish in their movements and succumbed ultimately to a premature death. Besides these, a large number of whitish, hammock-like cocoons of the Dryinid parasite were to be met with commonly on the leaves of plants in the infested fields. At this time the adult Dryinids were to be seen in large numbers flitting about the infested fields. Invariably the nymphs were the chief victims. In no case could I see the adults parasitized. When full-fed, the chestnut-brown metapleural

PLATE XXI.



DRYINID PARASITE ON *SOGATA* SPP.

a , Larva X 33.

b , mouthparts of larva, highly magnified.

c , adult, female, magnified.

or anal sacs enclosing the nymphs within dehisce longitudinally, and whitish grubs come out (Plate XXI, fig. *a*). These move about but little, and spin a whitish hammock-like cocoon enclosing within it another cocoon of a thicker texture. On emergence the adult female Dryinid (Plate XXI, fig. *c*) ærates its limbs for some time, the antennæ being moved from side to side very rapidly. It then flies away with a dart, pounces upon an unwary nymph of the Delphacid-hopper, catches hold of it in its anterior legs and within the twinkling of the eye oviposits into it. The parasitized nymph lies prostrate for some time, until it is able to move about slowly on the leaf. With the appearance of the sac laterally or at the anal end, the nymph becomes slow in its movements and is not able to jump about actively. When the sac, enclosing the Dryinid grub within it dehisces, the parasitized nymph dies with its legs spread out wide apart.

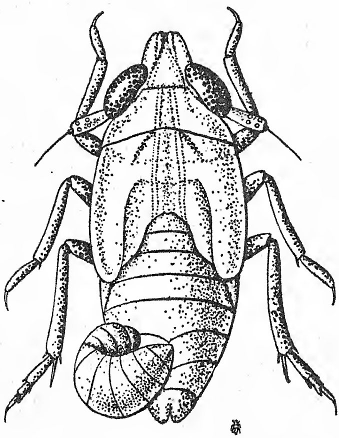


FIG. 5. Nymph of *Sogata* Sp. with Dryinid larva on its anal extremity (× 30).

The Delphacid leaf-hoppers, *Sogata pusana* Dist., *Sogata distincta* Dist., *Sogata pallescens* Dist. (Figs. 1, 2 and 3), oviposit in the tissues of the leaves. The females lacerate the tissues with their strong ovipositor longitudinally and deposit in them small whitish eggs. The colour of the eggs when laid freshly is pale-white, these deepen into dark-grey when fully matured with

two prominent spot representing the eyes of the nymph within. The nymph on hatching moves about the leaf until it comes upon a suitable succulent place to feed. It then thrusts in its rostrum and continues to suck the sap which would have otherwise gone to the maintenance of the plant. All this

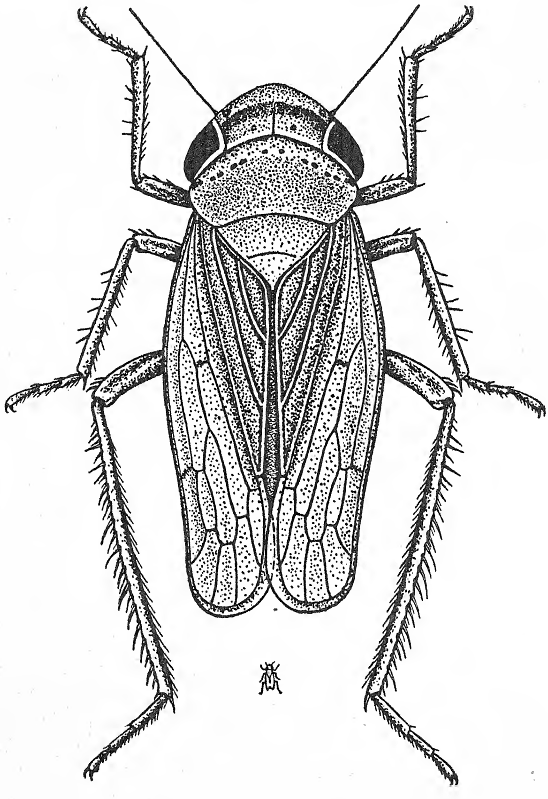


FIG. 6. *Athysanus indicus* (× 27).

time, it too, like the nymphs of the rice leaf-hoppers, *Nephotettix bipunctatus* and *N. apicalis,* exudes honey-dew in small, clear droplets which falling on the lower leaves form a thick matrix for the growth of the black fungus, *Capnodium* sp. The nymphs are very active and with the least jerk or disturbance jump off from leaf to leaf. The moults are passed on the leaves and the exuvia may be seen lying thickly on the infested leaves. The adults too are very active, but are not attracted to light. It was a species of this genus that appeared in enormous numbers in the Burdwan Division in Bengal in 1907, and devastated practically the whole of the paddy crop in that division.

Besides these, two species of *Oliarus* are also found on the paddy plants along with the following leaf-hoppers.

1. *Athysanus indicus* Dist.

[*Fauna of India,* Vol. IV, pp. 344-345.]

This hopper occurs mostly in green grasses on field-embankments, but with the least disturbance jumps off and settles on the paddy plants in the field. It is somewhat smaller than *Athysanus fusconervosus,* but can be distinguished readily from the latter by the presence of an arcuate impressed line near the anterior margin of the pronotum on which there are more or less distinct brownish or piceous spots (Fig. 6).

2. *Athysanus fusconervosus* Motsch.

[*Faùna of India,* Rhynchota IV, p. 344, Fig. 219].

This is a greyish-ochraceous leaf-hopper with a black curved transverse fascia between the eyes. The adult may be seen on the plants along with the two species of the rice leaf-hoppers.

3. *Thomsoniella albomaculata* Dist.

[*Fauna of India,* Rhynchota IV, p. 280, Fig. 179].

This is a pale or greenish-ochraceous leaf-hopper (Fig. 7) which is seen on the paddy plants, as well as the green, succulent grasses on the boundaries of fields along with *Thomsoniella porrecta* Walk. [*Fauna of India,* Rhynchota IV, p. 278, Fig. 178] and *Thomsoniella* sp.

4. *Tettigoniella spectra* Dist.

[*Fauna of India,* Rhynchota IV, p. 211, Fig. 137].

In some parts of the Bilaspur District, especially in the Sakti State this pale flavous leaf-hopper was very abundant with two other species of *Tettigoniella.* The adult hoppers were to be seen in large numbers on the leaves and the stems of the paddy plants, as well as the green grasses on field-embankments. The female lays eggs in a longitudinal line in the leaves sheathing stems and the nymphs that hatch out remain feeding on the leaves.

In some instances the eggs were found parasitized by a very small, pale-yellow Chalcidid. The parasitized eggs turn dark-grey in colour and when the adult parasite has emerged there is a round hole in the egg-shell.

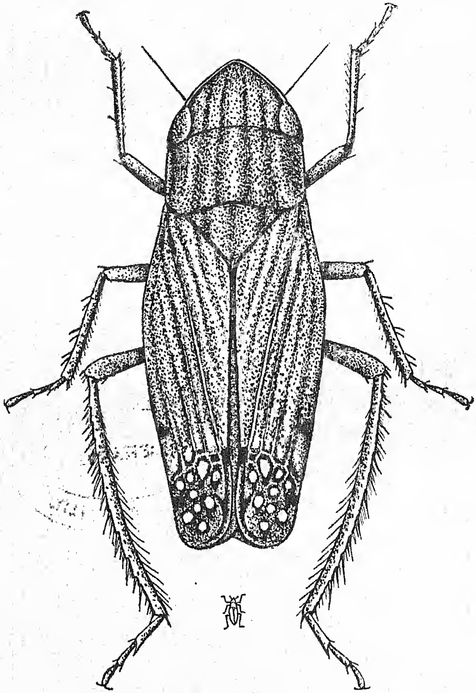
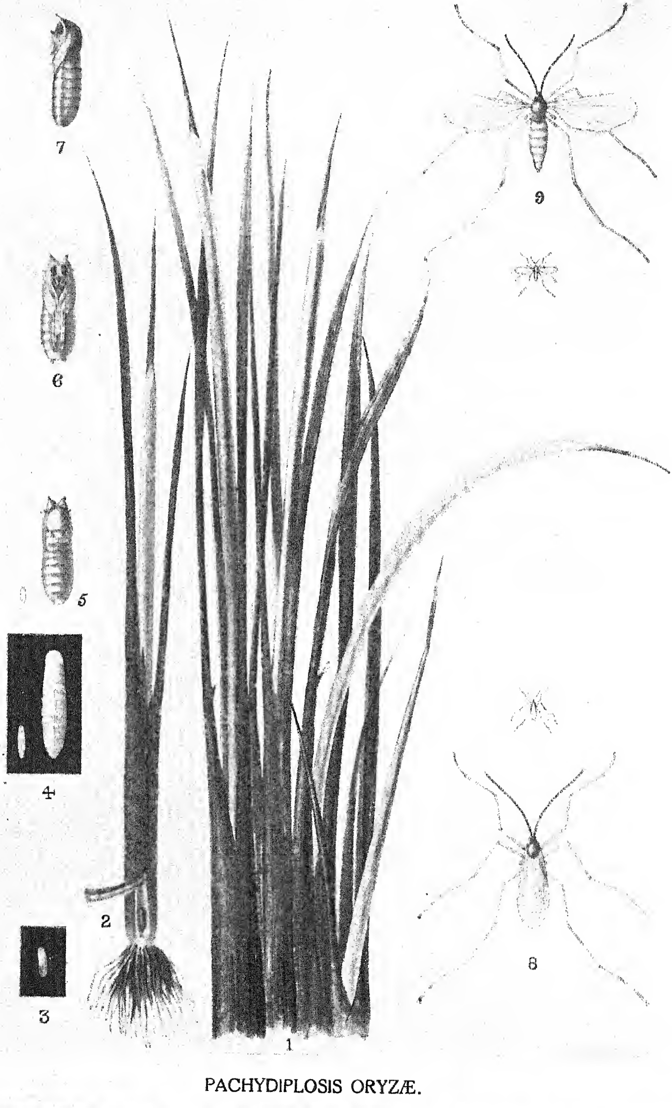


FIG. 7. *Thomsoniella albomaculata* (× 20).

5. *Kolla* sp.

[*Fauna of India*, Rhynchota IV, p. 223].

This leaf-hopper superficially resembles *Tettigoniella spectra* found in large numbers on the paddy plants as well as the grasses, its habits and



PACHYDIPLOSIS ORYZÆ.

EXPLANATION OF PLATE XXII.

Fig. 1, a cluster of rice plants several of which are affected.

Fig. 2, an affected plant, with the pupa in its natural position exposed.

Fig. 3, egg enlarged.

Fig. 4, full-grown maggot.

Figs. 5 to 7, different views of pupa.

Figs. 8 and 9, the adult fly in sitting and flying attitudes.

The small outline figures indicate natural sizes.

have

development are very much like the rice leaf-hoppers with which it is likely to be confused. The adult female deposits the eggs in the tissues of the leaves as well as the stems, and the places oviposited present an oval swelling if examined very carefully with a handlens. The number of these hoppers was not very large, and it was rather difficult, if not impossible, to distinguish them in the fields from *Tettigoniella spectra.*

6. *Selenocephalus virescens* Dist.

[*Fauna of India*, Rhynchota IV, p. 291].

This has been reported to occur in large numbers along with *Nephotettix apicalis* at Champhai in the Lushai Hills. In the lot of specimens received for identification it was found that the number of these was fairly large and it is possible that on some future occasion, provided the climatic and other conditions are favourable to its development and rapid multiplication, it might take the place of *N. bipunctatus* and run concurrently with *N. apicalis* in the particular region referred to above.

7. *Paramesus lineaticollis* Dist.

[*Fauna of India*, Rhynchota IV, p. 294, Fig. 186].

8. *Clovia puncta* Walk.

[*Fauna of India*, Rhynchota IV, p. 94].

A small, pale, tawny-brown Cercopid leaf-hopper with a black spot at posterior angle of inner margin of tegmina. The adult hoppers were to be seen in larger numbers in the green grasses on field-embankments rather than on the paddy plants. On account of its colour and compact appearance it can be distinguished readily from other leaf-hoppers (Fig. 8).

In the Cuttack and the Balasore districts in the Province of Bihar and Orissa, the rice stem-fly, *Pachidiplosis oryzalis* W. Mason, occurred at about the same time as the two rice leaf-hoppers were running their course (Plate XXII, fig. 8). The affected plants turn pale-green in appearance, and the stems become elongate and converted into hollow tubes with small leaflets on the top. The diseased plants become stunted in growth and do not produce ears filled with grain. In some villages the damage done by the Cecidomyiad fly was very great indeed, but in others there were affected patches scattered all over the rice area. The flies were very prominent during August-September, but their number diminished by the middle of October. Locally, the disease is known as *Thenga* (meaning 'a rod') and is so called on account of the characteristic malformation of the stems. On cutting open and examining the affected stems, I invariably found the pupæ of the fly. A few adults

were also seen by me in the infested fields, but the number was not very large.

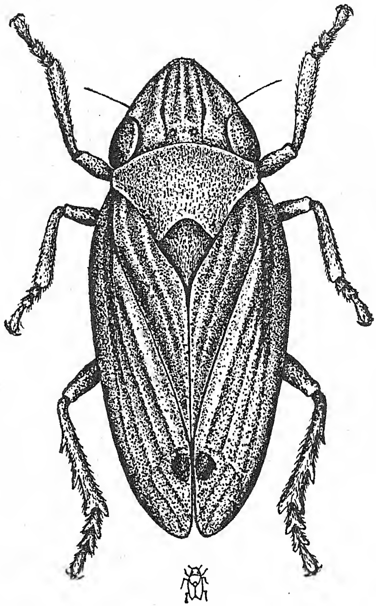


FIG. 8. *Clovia puncta.* (× 13).

Besides these, *Schœnobius bipunctifer*, *Cnaphalocrosis medinalis* and *Chapra mathias* were also present in some numbers in paddy fields affected by the leaf-hoppers.

Parasites and Predators.

The number of parasites and predators hitherto observed on the leaf-hoppers is not very large. The eggs are parasitized by a small, pale-yellow Chalcidid (Fig. 9). The parasitized eggs turn black and the adult parasites emerge by making clean, circular holes on the egg-shell which remain embedded in the tissues of the sheathing leaves. Such parasitized eggs were found by

ine at Janjgir in the Bilaspur District, as well as at Pusa, but the parasites could, in no sense, be said to be an effective check to the development of the

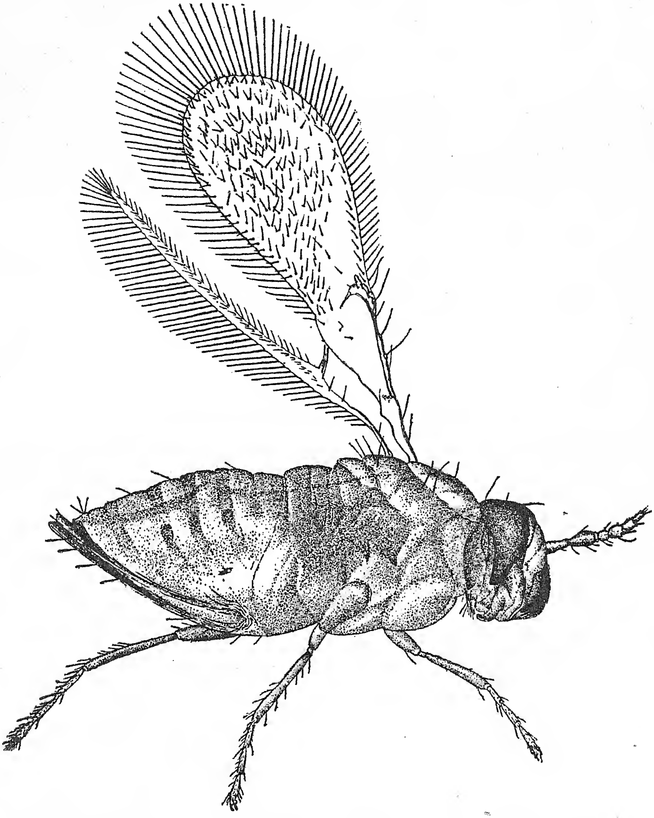


FIG. 9. Chalcid parasitic on eggs of *Nephotettix bipunctatus* and *N. apicalis* (× 150).

leaf-hoppers as the percentage of parasitized eggs was extremely small. Besides these, the nymphs of the leaf-hoppers were found by me at Janjgir in the Bilaspur District to have blackish bags of a Dryinid protruding from their meso—as well as metapleural regions, but all my attempts to rear out the adult parasites were not successful. The number of such parasitized nymphs was very small and the few that were collected were obtained after a long and weary search. Besides Janjgir, no such parasitized nymphs were found by me in other hopper-infested areas in the Sambhalpur and the Balasore districts in Bihar and Orissa. In a village in the Bilaspur District, a number of egg-masses were found infested by a small pale-yellow mite which found its way in through a small hole on the egg-masses. It could not, however, be ascertained definitely whether the mites entered before or they found their way in after the parasites had emerged, but it was certain that the mite-infested egg-masses turned deep brown in colour and failed to hatch in proper time. In fact, all attempts to find an effective parasite which would keep down the pests proved abortive. As is usually the case, in cases of serious and sudden outbreaks of pests, like the present ones, a small percentage of parasitized eggs as well as nymphs, is to be met with, but the question from an economic point was whether these parasites could be counted upon to check the hoppers to any appreciable extent. That such was not the case was borne out from a number of observations made to this effect in a number of places in the worst infested areas. In short, no such parasites and predators were noticed during the years that the hoppers were under observations which could be said to have kept them in check effectively.

Measures tried.

From the life-history of the hoppers given above (pages 213–219) it will be seen that the only vulnerable point in the life-cycle of the pests is their strong predilection for light. To take advantage of this, the adoption of lantern traps was recommended on a large scale. But owing to the prevalence of the war, when every thing was very dear, the right kind of oil could not be obtained locally to be used in the lanterns. All that was available was a very low grade of petroleum, which when used in the lamps smoked badly and darkened the glass to such an extent that they were practically useless. In normal times, this would not have been the case, as kerosine oil of good quality could be obtained readily. Besides this, to obtain the best results it was necessary that the cultivators of a tract should have co-operated to destroy the pests, but the Chhattisgarhi cultivator is very superstitious and lethargic. No amount of persuasion could induce him to go to his fields in the night and lit

up the lamps, as he is mortally afraid of evil spirits, which, he thinks, hover over the fields at night. Had the measure only been adopted on a large scale in proper time, the results would have been very satisfactory. In some places the lamps were used when the hoppers were only in the nymphal stages, and as such could not be expected to come to light. In others, the lamps were set up in the fields in the months of July and August when altogether different insects, the Delphacid Leaf-hoppers (*Sogata* spp.), were present in enormous numbers on the plants. But as these insects are not attracted to light, the lamps could not be said to have served their purpose. To get optimum result by the use of lantern traps it is first necessary to determine, whether the *Mahos* are actually present in the fields or it is some other insect or insects which have preceded them. If this discrimination is not made, time, money and energy employed in the use of lantern traps on a large scale over a wide area are likely to yield no substantial results. Before putting out the lantern traps it is necessary to have the crops examined by an entomologist and then to adopt measures suited to the local conditions.

Besides the lantern traps the following measures were also tried :—

1. Torches or *mashals* made from material obtained locally, were set up at the corners of infested fields in *Gehunras* areas (lands adjoining villages). But from observations conducted on a number of days it was found that these were not effective, as few *Mahos* were attracted to them.

2. Bonfires were lit up either on the embankment of fields or other prominences in the vicinity of rice areas, and it was found that these were not effective and as such were given up.

3. Kerosine oil was squirted on the surface of the water of the infested fields and a rope was passed over to dip the plants in the water. But it was found that in large fields the rope sagged in the middle and in consequence the plants at the sides did not bend sufficiently to come in contact with the water. If the fields were large, a man was told to hold the rope in the middle and to walk slowly in the middle. In small fields, the rope passed well over the plants but the hoppers jumped off to other plants and thus escaped destruction. In adopting the measure on a large scale, it was necessary to obtain labour locally, but this was not obtainable readily.

4. Bagging the infested fields with field-bags. It was found that a bag 4 ft. long attached to a light bamboo frame 6 ft. long by 4 ft. broad worked well (Plate XXIII, fig. 1). Prior to working it, kerosine oil was squirted in the interior either with a syringe or a sprayer. The bag was worked at a walking pace and against the direction of the wind. If, however, it became a calm or the wind stopped suddenly while the bags were at work, the cloth sagged and fell heavily

on the plants which broke off from the middle. In some places, the cultivators were induced to sprinkle kerosine oil on their *dhotis* and to work them in the *Maho*-infested fields against the direction of the wind. It was found that 4 men working a bag alternately could bag an area of 6 acres in 10 hours. The bag described above could be made locally for Rs. 2 to Rs. 2-4, but now, as the price of the cloth has gone up, it will cost a little more.

MEASURES RECOMMENDED FOR ADOPTION.

The pests have not been reported since 1915, but as they are sporadic serious pests, it is necessary to adopt such preventive measures as may prevent their recurrence. The causes which have brought about this change are not well understood at present, and the observations recorded in this Memoir represent two years' work in the infested tracts in the Chhattisgarh Division of the Central Provinces. But so far as is known, it is certain that the climatic conditions play no mean part in the development and subsequent multiplication of the pests. If, however, there are good rains after the paddy crop has been harvested, and in consequence the stubbles in the fields tiller well, it is possible that the pests, finding abundant food-plants, might reproduce quickly, and if there are no heavy rains in August–September but a spell of hot sunny days, there is every possibility of the pests damaging the crop to some extent. What this would approximately be, nobody can foretell. It would then be advisable to adopt the following measures :—

(1) To impress upon the local cultivators the absolute necessity of clean cultivation, to allow no grassy-lands to remain in the immediate vicinity of rice-areas.

(2) To impress upon the local cultivators the necessity of allowing cattle to graze freely in the barvested areas, as well as in the dry beds of ponds and streams where grasses grow luxuriantly.

(3) To bag the nurseries with hand-nets or *dhotis* previously moistened with kerosine oil.

(4) To bag the areas in July–August if there is a break in the rains and if the days are hot and sunny. The bagging should be done preferably with large field-bags 6 ft. long, 4 ft. broad with a cloth-bag 4 ft. deep attached to a light bamboo-frame (Plate XXIII, fig. 1). The bags should be worked at a walking pace and against the direction of the wind. The inside of the bags should be moistened with kerosine to prevent the hoppers, when once they have got in, from getting out. The contents of the bags should be emptied in vessels containing water and a little kerosine on top of it. In case there is much water in the fields, it is better to drain them and to attach the cloth-bag to two upright

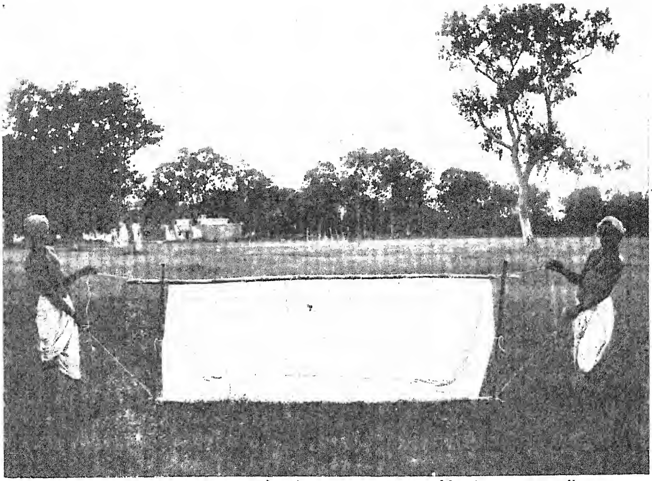


Fig. 1. Field-Bag (Type A) to be used when the paddy plants are small.

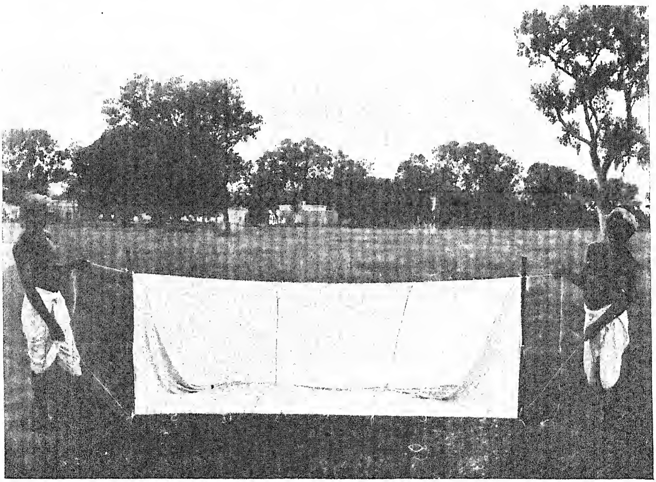


Fig. 2. Field-Bag (Type B) to be used when there is much water in the fields.

bamboo poles 4 ft. long. This prevents the plants from breaking off with the impact of the cross-bamboo poles of the bag (Plate XXIII, fig. 2).

(5) Kerosine oil should be squirted on the surface of fields containing sufficient water in them and a rope should be drawn across them by two men so as to shake the plants. By doing so the nymphs as well as the adults come in contact with the kerosine and are destroyed.

(6) To set up lantern-traps during July–August when the adults are about and there is a break in the rains with hot, sunny days. As the adults have a strong predilection for light they will be attracted to the light-traps and will be destroyed. Thus the future generations will be restricted considerably and even if damage be done it will be slight only. Before setting up lantern traps it should be determined, as accurately as possible, whether the *Maho* or some other insect is actually present. If the latter are present and if the lantern-traps are set up, no good would accrue as it would not be possible to ascertain for certain if these too have a predilection for the light. Bagging and setting up of lantern-traps, if adopted at proper times, are expected to yield very satisfactory results; whether this is so or not, future outbreaks would only show.

Besides these, if the pests again break out hereafter and run consecutively for a series of years, it would then be worth considering the question of selection of such varieties of paddy as are wholly or partially immune from the attacks of the hoppers. The question of early-ripening varieties will have to be considered also and it is a fact, that the cultivators in the worst infested tracts in the Chhattisgarh Division of the Central Provinces, after their said experience for two years, actually sowed early-ripening varieties over a large area during 1915 and 1916.

Summary.

The rice leaf-hoppers were first heard from Sambhalpur, Bihar and Orissa, in 1910, as specific pests of rice, and four years later they were reported to have damaged 300,000 acres, causing a loss approximately of fourteen million rupees in the Chhattisgarh Division only of the Central Provinces. At the instance of the Director of Agriculture, Central Provinces, observations were begun and measures were tried during 1914 and 1915 and these are incorporated in this Memoir. The pests have not been reported from the Chhattisgarh Division, Central Provinces, since 1916 and it is presumed that the prompt adoption of measures early in 1915, prevented the pests from establishing themselves in the infested area.

ACKNOWLEDGMENTS.

Considerable help was received from the Department of Agriculture, Central Provinces, and I have to thank Mr. D. Clouston, M.A., Offg. Director of Agriculture, Central Provinces, for allowing me the services of the Agricultural Inspectors at a time when the situation was very grave. I have also received considerable help from G. D. Ojha, Fieldman to the Imperial Entomologist, Pusa.

June 1919.

LITERATURE CONSULTED.

Fauna of India	W. L. Distant, Rhynchota., Vol. IV, pp. 359-362. 1908.
Indian Insect Life	H. M Lefroy, p. 738. 1910.
Die Schädlichen und Nützlichen Insekten Vom Zuckerrohr Formosas	Dr. S. Matsumura, p. 21. 1910.
Some South Indian Insects	T. Bainbrigge Fletcher, p. 497. 1914.
Report on investigations regarding the *Maho* (*Nephotettix bipunctatus* and *N. apicalis*) in the Central Provinces	C. S. Misra. October 1915.
Studies of Life Histories of Leaf-hoppers of Maine	Maine Agricultural Experimental Station, Orono. Bull. No. 248. 1917.
Proceedings of the Second Entomological Conference	Pusa, pp. 176-177. December 1917.
Insects attacking paddy in the Galle District. Tropical Agriculturist	Peradeniya Ceylon 1. No. 3, pp. 153-158. March 1918.
Review of Applied Entomology	Vol. VI, Series A, Part 7, p. 295. July 1918.

PREFACE

The following Report, by Rao Sahib Y. Ramachandra Rao, deals with an investigation regarding the insects found on *Lantana* in India, made with the idea of discovering whether there exists in the Indian Empire any insect which is capable of proving an effective check upon this plant. The author has given an excellent account of his work and his Report will perhaps assist to bring home the facts not only that *Lantana* has been distributed until it has become a noxious weed in most parts of India and Burma, but also that various other plants which have been introduced for ornamental purposes have also got, or are getting, out of hand and are likely to prove sources of considerable trouble and expense to the country in the near future. What seems to be required is a regular Weed Survey and the adoption of necessary restrictions on the spread of noxious species *before* they have got out of hand.

Lantana is itself an excellent example of the danger of the indiscriminate introduction of a plant which, originally introduced as an ornamental shrub on account of the beauty of its flowers, has escaped from cultivation and become a nuisance in many districts and a regular pest in localities which have suited it. India is not the only country which has suffered, for *Lantana*, originally a native of South and Central America, has been introduced by man into most parts of the Tropics, and in all suitable localities it has run wild and proved itself a noxious weed. I myself have seen a good deal of *Lantana* and have paid some attention to its spread, not only in India, but also during four years' experience in Ceylon and also in Hongkong, Singapore, Mauritius and the Seychelles, in all of which localities it has run wild and displaced the native vegetation.

The Hawaiian Islands form one of the best known cases of the invasion of *Lantana* on account of the measures taken there to combat it by means of its natural insect enemies, which appear to have checked its spread efficiently. These insects were brought from Mexico where Mr. Koebele spent some time in investigating the insects attacking *Lantana* and those which he considered of importance as a check and safe as regards other vegetation were sent in numerous consignments to Hawaii, where they were

handled by Dr. Perkins, who again carefully selected and liberated only the best and safest species. It should, however, be remembered that the conditions in Hawaii are peculiar and markedly different from those in India, owing primarily, as Dr. Perkins has said, to the remote position of this group of islands whereby the limited indigenous fauna gave free scope for increase to the new arrivals, the general absence of creatures injurious to the introduced beneficial species, and the equability of the climate, allowing of almost continual breeding, affording results which could hardly be attained elsewhere on the globe. The keen struggle for existence of continental lands is in Hawaii comparatively non-existent and, so far as it exists, is rather brought about by the introduced fauna than the native one. It is by no means certain therefore that the Agromyzid which has been claimed as successful in attacking *Lantana* seeds in Hawaii and which has been introduced from Hawaii into Noumea, Fiji and Australia, would be equally successful if introduced into India. It must not be overlooked also that in Hawaii this Agromyzid has attacked *Lantana* in the almost complete absence of any other closely-allied plants. In a letter to me, in reply to a request for information on certain points regarding the control of *Lantana* by insect pests, Mr. D. T. Fullaway, Entomologist to the Board of Commissioners of Agriculture and Forestry, Hawaii, states that he knows of only one tree (*Vitex trifolia*) which has drupaceous fruits like *Lantana* and suitable for the work of the Agromyzid but he is unaware of any attention having been paid to the question of whether the *Lantana* Agromyzid has also attacked these fruits. In India, on the other hand, the Natural Order Verbenaceæ (to which *Lantana* belongs) is represented by numerous common species belonging to the genera *Verbena*, *Duranta*, *Tectona*, *Gmelina*, *Vitex*, *Clerodendron*, *Avicennia*, etc., some of which might prove suitable alternative foodplants, should this Agromyzid be introduced with the object of checking the spread of *Lantana* in India. Experience alone can tell whether it would or would not attack such other allied foodplants and such experience would probably only be attained after such thorough establishment of the Agromyzid that its extermination, if considered desirable, would be impossible. As Dr. L. O. Howard has well remarked (*Journ. Econ. Entom.*, VIII, 456), "the introduction of insects to feed upon weeds or other plants is a dangerous experiment and it is very fortunate that it turned out so well in this case." Mr. Fullaway, who is probably more familiar with the subject than anyone else on account of his practical experience in Hawaii, writes :—"I consider that you are quite right in approaching the matter with caution. I myself am not prepared to go further than to say that the insects have been a distinct benefit here." I cannot therefore recommend

the introduction into India of this Agromyzid without previously making sure, as far as is possible, that it will confine its attention strictly to *Lantana*.

Rao Sahib Ramachandra Rao's investigations have brought to light a long list of insects also present and attacking *Lantana* in India and Burma. The most efficient of these is *Platyptilia pusillidactyla*, a small Plume-moth whose larva feeds in the flower-heads and reduces the output of seeds to a considerable extent, attacked flower-heads producing only a few sickly berries instead of a number of healthy ones. It is already widely distributed throughout India, Burma and Ceylon, and would be even more efficient than it is were not its numbers considerably reduced by the attack of Hymenopterous parasites.

In any case, it should be noted that no insect is likely to do more than act as a check, *i.e.*, many seeds will be unattacked and will be spread. I doubt whether any form of insect control will obviate altogether mechanical methods such as cutting and burning, and I have seen a good deal of *Lantana* under very varied conditions in and outside of India. Even under the extraordinarily successful conditions in Hawaii, *Lantana* has not been exterminated and its spread has only been checked to some extent.

In the meantime vigorous efforts should be made to check the spread of *Lantana* in those districts in India and Burma which are at present only lightly infested and to prevent its entry into areas hitherto unaffected. It is folly to wait until a pest of this kind has got out of hand before attempting to tackle it.

T. BAINBRIGGE FLETCHER,
Imperial Entomologist.

PUSA:
The 22nd June, 1919.

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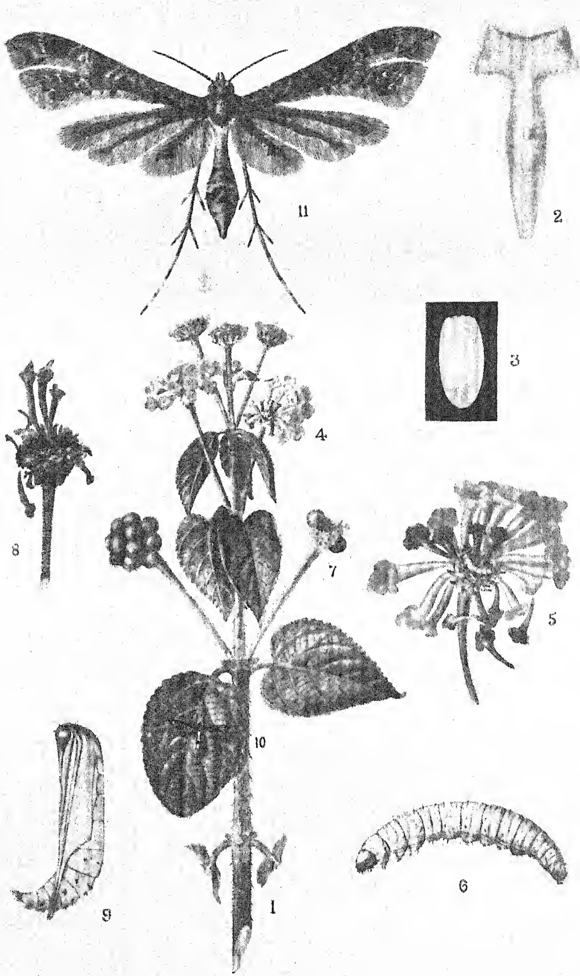


PLATYPTILIA PUSILLIDACTYLA.

Explanation of Plate XXIV.

Platyptilia pusillidactyla.—

1. Twig of *Lantana camara*, showing leaves, flowers (orange-yellow variety) and fruits (natural size).
2. Egg, as laid on flower, magnified (×7)
3. Egg, more highly magnified (×43).
4. Flower attacked by larva. Note sickly appearance in comparison with healthy flower on left.
5. Flower attacked by larva, opened up, showing larva at base of flowers, magnified.
6. Larva, magnified (×7).
7. Fruit-cluster formed from flower-head in which a larva has fed and pupated. Note scanty formation of fruits in comparison with healthy cluster on left.
8. Enlarged view of attacked flower-head in which a larva has pupated. The head of the pupa is seen projecting from the interior of cocoon which has been partially opened.
9. Pupa, magnified (×7).
10. Moth, in resting position, natural size.
11. Moth, with wings expanded, magnified.

LANTANA INSECTS IN INDIA.

BEING THE

REPORT ON AN INQUIRY INTO THE EFFICIENCY OF INDIGENOUS INSECT PESTS AS A CHECK ON THE SPREAD OF *LANTANA* IN INDIA.

BY

RAO SAHIB Y. RAMACHANDRA RAO, M.A., F.E.S.,

Entomological Assistant, Madras (on Special Deputation on Lantana *work under the Imperial Entomologist).*

[Received for publication on 27th June, 1919.]

1. INTRODUCTION.

Lantana aculeata (= *camara*) is one of several species of the genus which are indigenous to America. Being the happy possessor of indisputably beautiful flowers, it has come within the purview of the Horticulturist always in search of fresh acquisitions to beauty in the floral world. Originally introduced into Botanical gardens and thence distributed for purposes of a live fence, it has travelled from land to land until it has become a denizen of almost all the tropical regions of the world. Nowhere did the people realize how much harm the plant was capable of, until it was beyond their power to check it. The fruits being edible, birds were soon noted feeding on them and functioning as active agents in the dispersal of its seeds, so that within two or three decades the plant turned into a troublesome weed of the first magnitude. In Hawaii *Lantana* appears to have been introduced about 1858; by the eighties it had increased enormously and become a serious problem for the ranchmen (*Tropical Agriculturist*, Apr. 1904, p. 657). About 1900, Mr. A. Koebele, an Entomologist in Hawaii, with previous experience in the introduction of parasites, hit upon the idea of examining the plant in its reputed original home in Mexico. He actually visited Mexico in 1902 and his

examination of *Lantana* in that country led to the discovery of innumerable insects feeding on it and keeping it in complete check in its home. Out of nearly 400 different insects noticed as pests on the plant, he selected those that might be introduced into Hawaii with safety, carefully eliminating those that were pests on economic plants, as well as those that might be suspected to have leanings in that direction. Out of the numerous insects noted by him, he sent by parcel live material of only 19 different species to Dr. Perkins at Hawaii, who in turn, after selection, set free practically only eight of them. (*Hawaiian Forester*, Vol. VI, No. 8, p. 328; O. Swezey, *Journ. Econ. Entom.*, Vol. VIII, Oct. 1915, p. 453). Among these, the success of the seed-Agromyzid, the maggot of which feeds inside the immature *Lantana* berry and destroys its germinating power, was reported to be instant and phenomenal. The rest consisted of

2. 2 *Moths*: *Platyptilia pusillidactyla* } The larvæ of which feed on
3. *Crocidosema lantana** } flower clusters.
4. 2 *Butterflies*: *Thecla echion* } Larvæ feeding on flowers.
5. *Thecla agra* }
6. A Microlepidopterous moth: *Cremastobombycia lantanella*, a miner in leaves.
7. A Tingid bug: *Teleonemia lantanæ*, feeding on the underside of leaves and causing them to fall off.
8. A Gall-fly: *Eutreta sparsa*, causing swellings in freshly growing shoots.

While all of them have proved effective checks on *Lantana* none of them, it is reported, has become injurious to any cultivated plant in Hawaii. "The insects, of course, did not exterminate *Lantana* but were highly effective in checking any further spread of the plant and rendered it possible for any one to clean *Lantana*-covered land once and for all, without fear of having to perform this work at intervals of every few years." The usefulness of the introduction of Mexican insects into Hawaii was, however, somewhat marred by the importation, privately, by ranchmen from a neighbouring island, of the *Lantana* Bug, *Orthezia insignis*, which is polyphagous in habits.

The successful results achieved by this method in Hawaii induced various other Governments to try it in their country. In 1908-09 a shipment of the seed-fly was reported to have been made for New Caledonia from Hawaii (Tryon, *Queensland Agr. Journal*, Dec. 1912), and in 1912 the fly appears to

* This species is not included in the *Fauna Hawaiiensis*, but was described by Busck (*Proc. Ent. Soc. Wash.*, XII., 132 [1910]) from Central America and Hawaii. The only Indian species of this genus (*C. plebeiana*, Z.) is attached to Malvaceæ. [T. B. F.]

have been successfully established there. According to Pamphlet No. 21 of the Fiji Department of Agriculture of 1916, Mr. F. P. Jepson, Government Entomologist, Fiji, visited Hawaii in 1910 and introduced the seed-fly in 1911. The pamphlet reports successful results.

Mr. W. W. Froggatt, Government Entomologist, New South Wales, up to as late as 1916 appears to have treated the subject with very great caution. He appears to have considered that the conditions in Australia were so different from those of an Island where the main crop may be sugarcane or coconuts, that no berry- or seed-eating fly should be brought in.

In Queensland, on the other hand, Mr. Tryon, with his world-wide experience in connection with the study of Cactus insects, sent Mr. Jarvis, Assistant Entomologist, to Hawaii in January 1917 and then to Fiji for bringing the seed-fly for introduction into Queensland. A large number of flies was successfully imported and liberated in March 1917 into Queensland.

The successful results reported in Hawaii, New Caledonia and Fiji, naturally raised the question as to why the introduction of the seed-fly should not be tried in India, to combat the heavy infestation of *Lantana* in the Forest areas of the Western Ghats. The Government of India referred the problem to the Imperial Entomologist and to various other responsible Entomologists in India for their individual opinion, whereupon all the Entomologists were, on the whole, unanimous in their note of warning as to the danger involved in importing foreign insects generally, owing to the possibilities of insects imported developing new and injurious characters and habits in their new environments. They were further of opinion that, before seeking to introduce Mexican insects from Hawaii, it was advisable to find out first whether in a vast country like India, there was not existent in some corner or other an indigenous insect, which was capable of checking the growth of *Lantana*. If such an insect was discovered, it would be far easier and safer to introduce that insect from one part of India to another, than to ship in a possible danger from distant lands.

Such was the genesis of my deputation for the purpose of making an inquiry as to the efficiency of existing indigenous insect pests on the check of *Lantana* in India.

2. ITINERARY.

On the 15th November, 1916, on receipt of orders from the Government, I was relieved by the Government Entomologist, Coimbatore, of my duties as Acting First Assistant, and since that date I worked under the immediate control of the Imperial Entomologist till the termination of the deputation on the 31st March, 1919. Under his instructions, I began work at Coimbatore.

Though *Lantana* is not abundant in that place, the time at which the work was started, being the end of the North-East Monsoon, was exceedingly opportune and numerous insects were noted on *Lantana* and a good beginning was made. Except for short visits to Mettupalaiyam, Kallar, Coonoor and Bangalore, I remained at Coimbatore till the end of January 1917. In February 1917, I visited Pusa in connection with the Second Entomological Meeting and also attended to the identification of insects collected so far on *Lantana*. In March 1917, I proceeded to Sidapur, Coorg, in accordance with the directions of the Imperial Entomologist, and remained there till the 15th July, excepting a period of about a month in June 1917 when I was away on privilege leave. Various places in Coorg were examined in May 1917. Bangalore, the Shevaroys and Coimbatore were visited in August, and the Nilgiris in September 1917. I awaited the arrival of the Imperial Entomologist early in October in Bangalore, but on receipt of a telegram to the effect that he had altered his programme, I visited some of the localities around Bangalore, such as Tumkur, in the Mysore State. Leaving Bangalore on the 25th October, 1917, I visited Coorg, Wynaad, parts of Malabar and the Anamalai Hills during the months of November and December. I was at Bangalore during Christmas and left the place for Pusa with the collection and records on the 16th January, 1918. Reaching Pusa on the 20th January, 1918, I remained there attending to the arrangement of the collections, the identification of insects reared on *Lantana* and the preparation of a preliminary report on the results of the *Lantana* investigation. On the 3rd February, 1918, I left Pusa for Burma under the instructions of the Imperial Entomologist. Leaving Calcutta by steamer on the 6th, I reached Rangoon on the 9th February and toured in Burma till the 12th May, 1918, visiting during this period the following places: Rangoon, Insein, Hmawbi, Prome, Moulmein, Thaton, Pegu, Pyinmana, Thazi, Meiktila, Mandalay, Maymyo, Anisakan, Hsipaw, Lashio, Kanbalu, Naba, Myitkyina, Bhamo and Kalaw. Leaving Rangoon by steamer on the 13th May, I reached Calcutta on the afternoon of the 16th and Pusa on the morning of the 19th May, 1918. Having been instructed by the Imperial Entomologist to join him at Shillong, I left Pusa on the 27th May and reached Shillong on the 29th. I worked in Assam till the 30th July, visiting during this period Shillong, Cherrapunji, Barapani and Gauhati. I returned to Pusa on the 1st of August, 1918. The Ramandrug Hills in the Bellary District were next examined and thence, after visiting Dharwar, Londa and Castlerock in South Bombay, and Shimoga, Sagar and Bangalore in Mysore, I returned to Pusa on the 26th September, 1918. The Punjab was next visited; reaching Gurdaspur on the 12th October, I paid visits to Pathankote, Madhopur, Dhariwal and Lahore.

Owing to certain domestic calamities that befell me during the influenza epidemic, I had to proceed home on privilege leave and during my absence Mr. G. R. Dutt of Pusa worked in my place, visiting Gurdaspur, Lahore, Sialkote and Jhelum. After an absence of 25 days, I returned to duty at Gurdaspur on the 19th November, 1918. On the 20th I visited Hoshiarpur and returned to Gurdaspur on the 22nd. Having received instructions by wire from the Imperial Entomologist, I moved down, on the 24th November, to Dehra Dun in the United Provinces. At Dehra Dun, I attended to the examination of *Lantana* and with the kind assistance of the Forest Zoologist and the other officers of the Forest Research Institute obtained information regarding the distribution of *Lantana* in India and especially with reference to the United Provinces, Bombay and the Central Provinces. I also visited Rajpur and Masuri. Kathgodam and Haldwani were examined between the 5th and the 14th December. A short visit was also paid to Nainital. Lucknow was examined on the 15th December *en route* to Gorakhpur where a stay of 12 days was made. Cawnpur was reached on the 28th December. Dariaogunj on the Cawnpur-Agra Branch of the B. B. & C. I. Ry. was examined on the 15th January, 1919. From Cawnpur I proceeded to Jabbalpur on the 7th January, whence after a stay of 4 days I moved down to Nagpur on the 12th January. From Nagpur I reached Ellichpur on the 20th and Chikalda in Melghat on the 23rd January. Leaving Chikalda on the 26th I reached Pusa on the 31st January, 1919. In February I attended the Third Entomological Conference and prepared a paper for the same. I stayed at Pusa till the 31st March, 1919, attending to the naming of *Lantana* insects and the preparation of this report on the results of the investigation.

Acknowledgments.

I beg to acknowledge with thanks the willing help received from the following gentlemen during the progress of this inquiry :—

Coorg. F. Hannyngton, Esq., I.C.S., then Commissioner of Coorg.

Father Cochet, of the Roman Catholic Mission at Virajpet, for identification of botanical specimens.

Coimbatore. Mr. T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., Ag. Government Entomologist, for kind loan of entomological apparatus and for kindly allowing me to work at his Laboratory during my stay at Coimbatore.

Mr. C. Tadulingam for kindly identifying botanical specimens.

Bangalore. Dr. L. C. Coleman, Director of Agriculture ; Mr. K. Kunhi Kannan, M.A., F.E.S., Senior Assistant Entomologist ; and Mr. Charles

Noronha, B.A., Mycological Assistant, for working at *Lantana* stems attacked by fungus.

Coimbatore. Mr. C. D. McCarthy, Conservator of Forests, Coimbatore.

Yercaud. Mr. R. W. B. Gompertz and Mr. Charles Dickins, Planters.

Nilgiris. Mr. J. F. Nicholls, Manager, Devarashola Estate.

Anamalais. Mr. J. H. Robinson, Valparai.

Pusa. Dr. F. J. F. Shaw, Second Imperial Mycologist, for identification of a fungus on *Lantana.*

Burma. Col. G. H. Evans, C.I.E., Superintendent, Civil Veterinary Department, Rangoon; Mr. A. Mackerral, Deputy Director of Agriculture, Insein; Mr. E. Thompstone, Deputy Director of Agriculture, Mandalay; Mr. T. Couper, Director of Agriculture, Maymyo; Mr. C. G. Rogers, Chief Conservator of Forests, Maymyo; Mr. C. Dixie Kiernander, Planter, Anisakan; Mr. K. D. Shroff, Assistant Entomologist; Mr. A. M. Sawyer, Assistant Botanist for identification of botanical specimens; and Mr. Phillips, Superintendent, Agricultural Horticultural Society's Gardens, Rangoon.

Assam. Mr. W. F. L. Tottenham, I.F.S., Conservator of Forests, Eastern Circle, Assam; Mr. A. W. Blunt, I.F.S., Conservator of Forests, Western Circle, Assam; Mr. Upendranath Kanjilal, Rai Bahadur, Retired Deputy Conservator of Forests, Shillong; and Mr. S. R. Gupta, Entomological Assistant, Gauhati.

The Punjab. Maulvi Fateh-ud-din Sahib, Deputy Director of Agriculture, Gurdaspur; E. A. A. Joseph, Esq., I.C.S., Director of Agriculture, Lahore; and Mr. W. R. Mustoe, Superintendent, Lawrence Gardens.

United Provinces, Dehra Dun. B. B. Osmaston, Esq., President, Forest Research Institute; C. F. C. Beeson, Esq., I.F.S., Forest Zoologist; R. S. Pearson, Esq., I.F.S., Forest Economist; and R. S. Hole, Esq., I.F.S., Forest Botanist.

Gorakhpur. Mr. Marriot, District Forest Officer.

Cawnpur. H. M. Leake, Esq., Principal, Cawnpur Agricultural College.

Central Provinces. D. Clouston, Esq., M.A., Director of Agriculture; R. G. Allan, Esq., M.A., Principal, Agricultural College, Nagpur; and Mr. J. L. Khare, Lecturer in Entomology, Nagpur.

3. THE *LANTANA* PLANT.

Lantana is a genus of world-wide distribution, belonging to the natural order Verbenaceæ and contains about 50 species, of which the greater number are natives of America.

Lantana aculeata, Linn. (=*camara*, Linn.) is, according to the *Index Kewensis*, a denizen of the Tropical American Region, comprising Mexico, Central America, Bolivia, Guiana, Brazil, etc. It is an introduced species in India.

"A large, much branched, gregarious, prickly shrub; branches quadrangular, grooved, clothed with recurved prickles. Leaves with the odour of black currants when crushed, ovate, acute at the apex, acute or rounded at the base, crenate-serrate, thick, scabrous above, softly pubescent beneath; lateral nerves 6 pairs, strong beneath; petioles 0·5″—1″ long. Flowers in peduncled, bracteate heads 0·5″—1·5″ in diameter; peduncles angled, 0·5″—3″ long, dilated at the top, pubescent; bracts ovate or linear, 0·2″ long; shorter upwards. Calyx small, membranous, pubescent. Corolla 0·25″ long, tube pink; limb pink or orange. Drupe 0·15″ in diameter, dull-purple, enclosed in the membranous calyx." Description from Talbot's *Forest Flora of Bombay*.

It is reported to have been introduced into Ceylon, first about 1824, and it is probable that it reached India about the same time.

Lantana indica is the indigenous representative of *Lantana aculeata* in India. It may be easily distinguished by the soft velvety leaves, the branches devoid of prickles, the long bracts, and the elongate flower-spikes. According to the *Index Kewensis*, the distribution of *Lantana indica* covers the whole of Tropical Asia and Africa.

Allied plants.

The following are some of the more common or important plants in India which belong to the same Natural Order Verbenaceæ and are thus related or allied plants of *Lantana*. A knowledge of these is important, as they are more likely to be affected than other Indian plants, in case foreign insects are imported to check the growth of *Lantana* in India.

1. *Lantana indica.* Shrub, found throughout India.
2. *Lippia geminata.* An introduced plant, naturalized in Eastern India.
3. *Lippia nodiflora.* A herb, found throughout India.
4. *Verbena bonariensis.* A Brazilian herb found naturalized on the Nilgiris and the Himalayas.
5. *Vitex negundo.* A shrub, common throughout India.
6. *Vitex altissima.* A large tree; Coorg, etc.
7. *Symphorema involucratum.* A climbing plant.
8. *Premna tomentosa.* A common shrub of South India and the Central Provinces.
9. *Premna integrifolia.* A small tree or shrub of South India.

10. *Tectona grandis* (Teak). A very valuable timber tree, throughout India and Burma.

11. *Tectona hamiltoniana.* A large tree, Burma, etc.

12. *Clerodendron inerme.* A common hedge-plant.

13. *Do. phlomoides.* A common South Indian shrub.

14. *Do. infortunatum.* Common herb.

15. *Callicarpa lanata.* Moderate-sized tree, common throughout India and Burma (The Coorg Lilac).

16. *Callicarpa arborea.* Tree of North India.

17. *Gmelina arborea.* Common tree.

18. *Gmelina asiatica.* Common shrub; South India.

19. *Sphenodesma* sp. Lower Burma.

The Vernacular names of *Lantana aculeata* in India.

Coorg. *Gulabi, Unni-gulabi* (lit. Tick rose), *Lanthana.*

Mysore Malnad. *Chadurangi, Chadurangada matte.*

Tamil country. *Unni chedi* (lit. Tick-plant), *Unni mullu* (lit. Tick thorn).

Malabar. *Arippū.*

Ramandrug. (Bellary District). *Kâki-gida.*

Dharwar. *Lavangada-kanti, Hesigé-kanti.*

Mahratta country. *Ghanéri* (evil-smelling), *Tântâni* (around Poona according to Cooke's Bombay Flora).

Chikalda, Melghat Taluq (Berar). *Rai-munia.*

Kathgodam (*Nainital Dist.*). *Kurai* (?), *Ban-Tulsi, Lal-thana.*

Cawnpur. Known sometimes as "*Khajur*" owing to its fancied resemblance to the *date-fruit.*

Madhopur (*Gurdaspur Dist.*), Punjab. *Panj-phuli.*

Assam. *Bon-mosla* (lit. wild spice) (according to Rai Bah. U. Kanjilal).

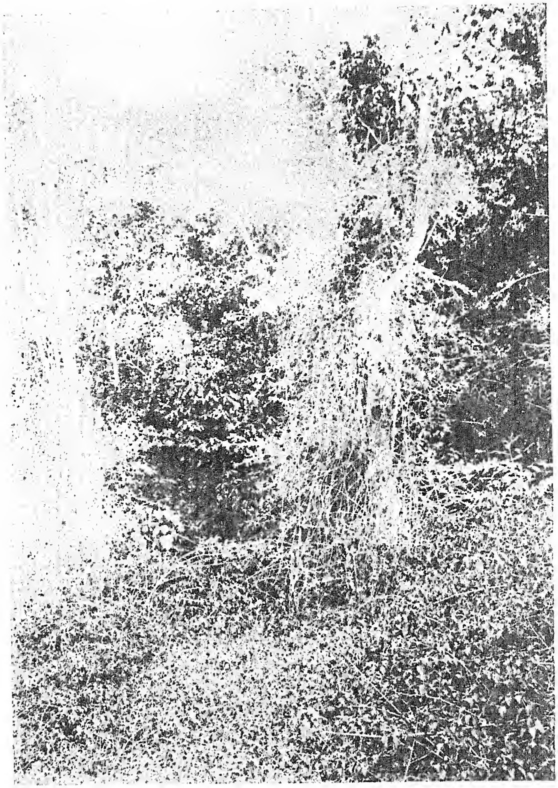
Khasi Hills. *Dieng-syntem-lahari* (Kanjilal).

Lushai Hills. *Hlow-rim-si* (Kanjilal).

Burma. *Sein-nagat-pan* (lit. diamond earring-flower), *Sein-naban-lit.* (diamond ear-ornament).

General characters.

Lantana aculeata is a large-sized shrub growing to the height of 3 to 10 ft., rarely attaining the size even of a small tree. In dry areas the bushes are stunted and the branches stiff and short, but in moist tracts the plant shows tendencies of spreading, the branches developing into thin and extremely long runners, not unusually measuring 30 or 40 feet. The branches of neighbouring bushes generally run into one another and become interwoven



Lantana climbing up a tree-stem at Sidapur, Coorg, April 1917.

into an extremely tangled mass, leading to the formation of very dense thickets, covering large areas of ground which neither man nor beast can penetrate. Where the requisite support is available, as around the stems of tall trees or around bamboo clumps, *Lantana* exhibits decided scandent habits, the branches climbing up along their sides, mainly helped by the grip afforded by their prickles. In some places *Lantana* is known to reach a height of nearly 30 feet. (Plate XXV.)

In almost all varieties that have run wild in India, prickles are prominently present, but in certain of the cultivated varieties they may be absent. The prickles generally drop off as the branches increase in girth and age. The leaves are generally rough above and hairy below; and there are some varieties in which the hairs are specially numerous.

The flowers are produced in close clusters of 25 to 50 and form corymbose heads borne at the top of long axillary peduncles. The flower is small and tubular, the limb being divided into 5 unequal lobes. The colour of the flowers is very variable and differs much in the different varieties. Moreover, the colouration of recently open flowers is different from that of flowers a day or more old, while in certain kinds a further change occurs as they grow older yet.

When fertilized, the flower-heads set into globular masses of rounded fruits. The immature berry varies in colour from a light to a dark green; as it ripens, it assumes a colour varying from a greyish blue to a bluish black. The fruit may, when fully ripe, drop to the ground or may sometimes dry up and remain attached to the peduncle. The fruit is a drupe.

It possesses a soft sweetish pulp enclosing a single "kernel" which is a top-shaped, more or less hollow, hard, bony structure. It is formed by the fusion of two pyrenes and contains two seeds lodged in distinct cells.

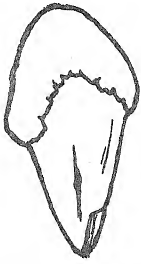


FIG. 1. Side-view of *Lantana* seed (×10).

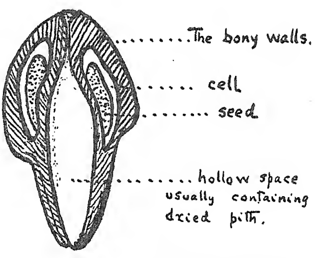


FIG. 2. Section through a *Lantana* seed (×10).

The "kernel," when cleaned, presents in certain aspects a curious resemblance to a head with a helmet on.

On the 14th March, 1917, a few seeds were placed in a shallow dish containing fine earth which was regularly moistened at intervals. The first seed germinated on the 26th March, 1917, and more were noted sprouting at intervals of 3 or 4 days. The last one actually observed to germinate was on the 28th May, after which observations were discontinued. Whereas in one case both the seeds in a stone sprouted at the same time, generally one germinated earlier than the other. One of the two was often a weakling. When sprouting the swelling embryo pushes open one of the projecting sides of the "helmet" and escapes to the outside and is thereafter quite unconnected with the "kernel". In view of the fact that in *Lantana*-infested areas the ground below the bushes is often covered with masses of fruits, which remain quiescent so long as they are denied sunshine, experiments for determining the length of time during which the seeds can retain their germinating power will be of much interest and great value.

Lantana is decidedly a surface-feeder and is shallow-rooted. The tap root may reach at the utmost a depth of about a foot, but usually radiates not much below surface-level into branches which divide and subdivide until the rootlets ramify the whole of the surface-soil. An examination of the soil under a *Lantana* thicket will easily show how thoroughly honey-combed it is with the ramifications of its root system.

LIFE-CYCLE.

The plant is a perennial and I have reason to believe is long lived ; I have not come across any bushes, in long established areas, that looked as if they were dying of old age. It is possessed of an extremely high vitality. It is capable of propagation by cuttings, and parts of stems or main roots, that may be left in the ground when the plant is carelessly cut, readily put forth shoots and regenerate the plant. In the moister tracts it flowers throughout the year, but in places affected by drought it may dry up partially or completely. Shoots and buds are always produced in abundance soon after the first heavy showers.

The sweetish pulp of the fruit renders it attractive to many animals, chiefly birds, and even to boys in the countryside. The fruits are generally swallowed entire and the hard seeds pass through the alimentary canal absolutely unharmed, and germinate wherever they are conveyed with the droppings of birds. The wide dissemination of this plant is thus, as in the case of *Ficus*, brought about mainly by the agency of birds. The ripe fruits when

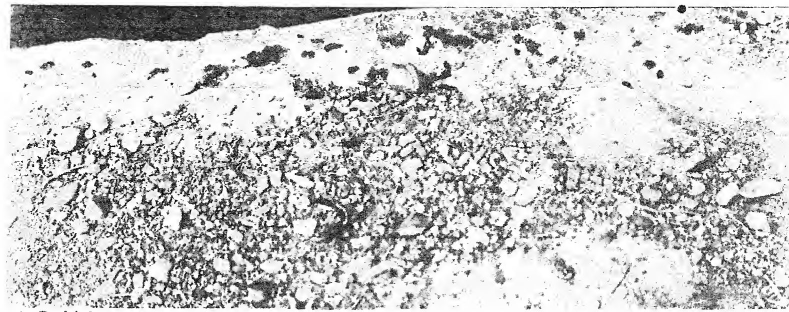


Fig. 1. Birds' droppings, consisting mostly of *Lantana* fruits, along edge of canal at Kathgodam, U. P., December 1918.

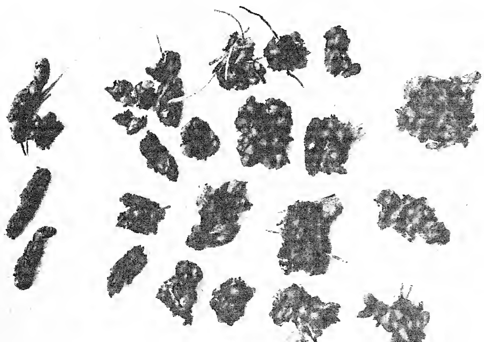


Fig. 2. Excreta of birds, containing *Lantana* seeds and found under trees at Dariaoganj, U. P., in January 1919.

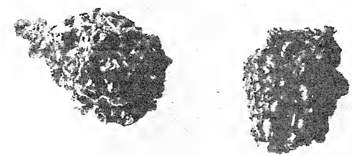


Fig. 3. Excreta of a mammal, containing numerous *Lantana* seeds; Ramandrug, July 1918.

dry are light and float on water. As *Lantana* bushes are generally fairly common on the banks of natural watercourses and along the margins of irrigation canals, it is quite conceivable to suppose that the dry *Lantana* fruits would be carried down the stream, especially when swept down by rain, and deposited in fresh localities lower down. This would appear to be another way by which the dispersal of the seed is brought about. The bird that goes to *Lantana* more than any other is the Bulbul, *Molpastes hæmorrhous,* which may be seen, especially of evenings, flitting about noisily from branch to branch on the bushes, and feeding on the ripe fruits. The sparrow, the mynah, the parrot, the crow and the ring-dove are some of the other birds that are known to feed on the ripe berries.

The excreta of the Bulbul are elongate, torpedo-shaped objects about an inch long, usually consisting of 3 or 4 *Lantana* seeds cemented together by a blackish mucoid matrix. They are generally noticeable under *Lantana* thickets, but, at Kathgodam, their droppings were found scattered in numbers on the brinks of the canals which they had the habit of frequenting when not on the bush (Plate XXVI, fig. 1). Another type of excreta, which were flattened and disc-shaped in the dry condition and contained several *Lantana* seeds, were noted on the sandy soil under trees at Dariaoganj in the United Provinces, and might presumably have been ejected in a semi-liquid condition by a larger bird, possibly the mynah or the ring-dove. (Plate XXVI, fig. 2).

In Coorg, at Ramandrug and at Chikalda on several occasions I came across mammalian excreta of fairly large size, dropped on the ground near *Lantana* bushes. They consisted almost entirely of uncrushed *Lantana* fruits and seeds, sometimes mixed up with bits of crushed elytra of beetles of sorts. From the size of the droppings and the evident inclusion of insects in the diet of the animal, it is very likely that the excreta belonged to an omnivorous mammal, possibly the jackal. (Plate XXVI, fig. 3).

I have on different occasions found ants gathering fallen berries of *Lantana* and carrying them to their nests : *Aphænogaster beccarii* in Coorg, *Myrmecocystus setipes,* and *Camponotus* sp.

Economic uses of *Lantana*.

Were it not for the tendency it has shown of escaping from cultivation, the plant would make an admirable fence and the dwarf varieties would make a very pretty show as permanent flower beds.

In Coorg I have found goats and sometimes cattle feeding on *Lantana,* chiefly on the flowers and the tender flushes ; but at Madhopur, in the Punjab,

and near Haldwani, *Lantana* was found to have the reputation of being poisonous to cattle, especially to those brought down from the Hills.

The wood is often used by the poorer classes as a cheap fuel.

At the Dasara Exhibition at Mysore baskets, purporting to have been made of the split stems and branches of *Lantana*, have been exhibited during the last few years, and presented as good an appearance as those made of bamboo.

I was informed that an essential oil had been extracted from *Lantana* leaves, at the Tata Research Institute, Bangalore, but I have no information as to whether the oil was useful economically, or whether the process of extraction was likely to be cheap enough to lend itself to manufacture on a commercial scale. Mr. R. S. Pearson, Forest Economist at the Forest Research Institute, Dehra Dun, informed me that the extraction of oil had been experimented with at the Institute, but that the extraction was too costly to be a paying concern, even if a demand for the oil were to develop.

I am also informed that immature berries of *Lantana* are, on the West Coast, sometimes put to a use, which neither adds much lustre to the reputation of the plant, nor certainly reflects much credit on the character of the ingenious person who utilizes it, *viz.*, the adulteration of green pepper berries for sale in the market.

VARIETIES OF *LANTANA*.

The *Lantana* plant, by reason of differences in the structure of the leaf and the stem and in the colouration of the flowers, is divisible into distinct varieties, and the number of such varieties to be found in India is indeed bewilderingly large.

As a great many of them are garden varieties which are of hybrid origin the work of differentiating, classifying and describing them is a task exceedingly difficult even for an experienced botanist, and is therefore clearly beyond my powers. However, for the purpose of this inquiry, at least a working knowledge of some of the principal varieties appears to be essential in view of the fact that the kinds that have run wild are different in different places, and have evidently been derived from garden forms, and also in view of the fact that at least one insect has shown decided preference to one particular variety.

Bailey in his *Cyclopædia of North American Horticulture* writes: "*Lantanas* have long been in cultivation and it is difficult to refer the garden forms to botanical species. The species themselves are confusing. There are several *camara*-like species which probably have hybridized to produce

Fig. 1. White *Lantana* hedge at Maymyo, Burma.

Fig. 2. *Lantana* hedge (red variety to left and white to right,) at Maymyo, Burma; April 1918.

Lantana varieties at Ramandrug, Bellary District, August 1918; pink (upper left), yellow (lower left), red (centre), pink and yellow (upper right), and pink and red (lower right).

these forms; but Voss, the latest garden monographer, regards these species as only forms of *Lantana camara* (preferring however to use the name *L. aculeata*). Accepting *Lantana* in Voss's sense, the garden *Lantanas* may be said to be derived from that species; this view is accepted below."

Classification of cultivated Lantanas (Bailey).

A. Plant spiny—fruit juicy.

L. camara Linn. (*L. aculeata* Linn.). Small shrub 1-4 ft. high, etc.; flowers in a dense nearly flat-topped head, usually opening yellow or pink, but changing to orange or scarlet. Tropical America, extending north to Texas and Granada.

Var. *nivea* (*Lantana nivea*, Vent.). Flowers white, the outer ones becoming bluish; heads rounder. This is evidently the *white Lantana* noted by me at Coonoor, Wynaad, Lashio, Maymyo, etc. (Plate XXVII, fig. 1 and XXIX, fig. 2).

Var. *mutabilis* (*L. nivea*, var. *mutabilis*, Hook.). Remarkable for the change of colour in the nearly globular heads: in little more than a day the flowers change from white through yellowish lilac, rose and blue. The outer flowers open white, run through yellowish, rose and lilac; the inner ones open yellowish.

The large-fruited pink variety, found by me at Coonoor and on the Nilgiris generally, is probably this variety.

Var. *mista* (*L. mista*, Linn.). Outer flowers opening yellowish and becoming saffron and brick-red: inner flowers changing to orange.

The beautiful form found around Shillong is probably this variety.

Var. *crocea* (*L. crocea*, Jacq.). Flowers opening sulphur-yellow and changing to saffron. Possibly this is the most common wild form (?).

Var. *sanguinea* (*L. sanguinea*, Medic.). Flowers opening saffron-yellow and changing to brick-red.

Possibly the wild form found by me at Dariaoganj (U. P.) belongs to this variety.

Lantana purpurea, Hornem. Erect: branches hairy with few recurved prickles, etc., etc.: flowers purple, very pretty, in hemispherical, umbellate heads: South America. A form of *L. camara* (?)

The purple varieties found at Bangalore, Coonoor and Madhopur (Punjab) probably belong to this variety.

AA. Plant never spiny: fruit thin-fleshed, usually not juicy.

Trifolia, Linn. (*L. annua*, Linn.). Half shrubby, hairy: leaves in 3's and 4's: heads becoming ovoid or oblong: flowers rosy-lilac, varying to white;

with yellow throat: fruit rather pulpy: Trop. America; found in gardens sometimes.

Sellowiana, Link and Otto (*L. delicatissima*, Host ?). Weeping or trailing *Lantana*: twiggy slender plant: leaves small: flowers small, in long-stalked small heads, rosy-lilac: S. America.

A very profuse bloomer: *Verbena*-like: the plant seems to be an escape in Florida.

Found by me in Botanical Garden, Rangoon (known as *L. delicatissima*) and in a garden at Lashio. (Plate XXIX)

Involucrata, Linn. Low much-branched bush: flowers small, equalled by the bracts: light lilac or white: Trop. America (cultivated). Not known to me.

Several of the varieties noted by me in various places in India do not fit into any of those mentioned above.

As already indicated above, one of the insect pests noted on *Lantana*, the gall-fly on the flowers (*Asphondylia* sp.), has been found attacking only the orange-red variety of *Lantana*, the commonest of the forms that have run wild, while the one which produces pink and yellow flowers is absolutely free. This gall-fly, on the other hand, breeds freely in flowers of *Lantana indica*. Such a sharp discrimination by the blind instincts of an insect point, in my opinion, to differences more profound than those between ordinary varieties. Very probably the orange-red one is the typical *L.* (*camara*) *aculeata*, while the pink-flowered plant is a distinct species.

However unwelcome the plant may have become owing to its aggressive propensities, the shady side of its character is undoubtedly much relieved by the possession of beautiful flowers. The richness and the variety of colours met with in the flowers, especially in the case of garden varieties resulting from hybridization, are indeed wonderful. The flowers may be pure white in one variety, while in another they may open light yellow with a saffron centre and gradually change into lilac with the centre scarlet. In a third, the recently open flowers are yellow and turn by degrees into saffron and brick-red, whereas in others again the whole cluster may be a rich crimson, a sulphur yellow or a light lilac. When the various varieties are judiciously mixed and kept within bounds by periodical clipping, *Lantana* makes an eminently handsome live fence and the effect produced by the masses of the many-coloured flowers is glorious.

LANTANA INDICA. (Plate XXX, fig. 1.)

It was noted in obundance in the drier regions of the Hills of South India. It was found around Coonoor at Runnymede and Katteri and around Kotagiri, on the Nilgiri Hills, on the eastern flank of the Anamalai Hills, and the greater

Fig. 1. *Lantana delicatissima.*
Lashio, Burma; April 1918

Fig. 2. White *Lantana* (left) and *Lantana delicatissima* (right);
Lashio, Burma; April 1918.

Fig. 1. Red *Lantana* (left) and *Lantana indica* (right); Sidapur, Coorg, April 1917.

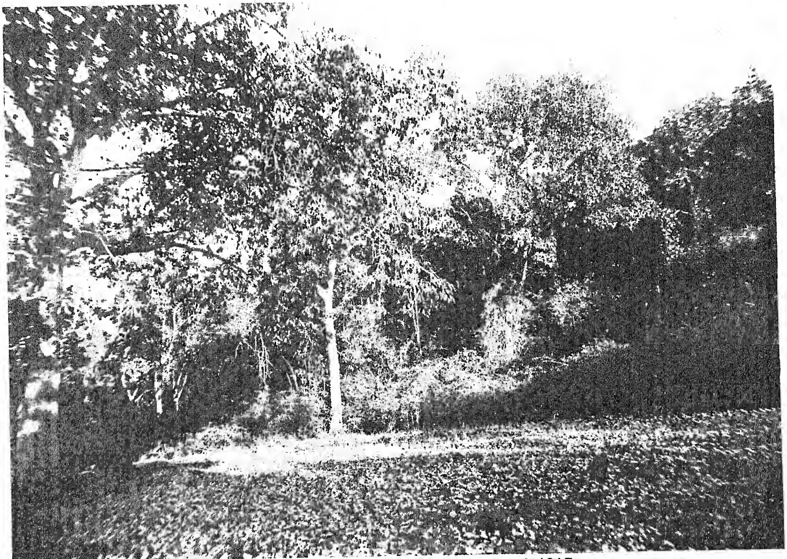


Fig. 2. *Lantana* at Sidapur, Coorg, April 1917.

part of the Shevaroys. It was rare on the more rainy portions, as for instance on the western parts of the Nilgiris and the Anamalais and in Coorg and the Wynaad. There seem to be at least three distinct varieties of the plant, so far as observed: (1) growing into tall bushes 3 to 6 ft. high, like *Lantana aculeata*, with purplish flowers, cream-yellow fruits and silver-grey leaves; found on the Nilgiris; (2) stunted plants, generally not forming bushes, with light purple flowers and deep purple generally large-sized fruits; found on the Shevaroys, Coorg, Anamalais, etc.; (3) low-growing shrubs, forming dense clumps, with diminutive leaves and clusters of small white flowers and greenish white fruits (= *Lantana indica* var. *albiflora*); found on the Nilgiris and Masinigudi (Mysore borders).

Though *Lantana indica* is said to be recorded throughout India, I did not come across any specimen in North India except one doubtful case near Kichcha Station in Haldwani District, U. P.

This plant, which is otherwise obscure and inconspicuous, acquires some importance in view of the fact that some of the major pests hitherto noted on *Lantana* also attack this plant, and there appears to be little doubt that it must have served as their original host-plant before they transferred their attentions to its imported cousin.

4. FERTILIZATION OF *LANTANA* FLOWERS.

Lantana is by constitution a butterfly-flower. The corolla tube is cylindrical and elongate and the nectary is situated at the bottom of the tube. The anthers are placed half way up on the sides of the corollary tube, while the stigma lies at the bottom slightly superior to the position of the nectary. The interior of the corolla is armed with a whorl of closely arranged upwardly directed hairs which seem to function as a defence against the entrance of ants and also to serve to prevent pollen-grains from the anthers dropping down onto the stigma.

When a butterfly visits a flower, it unfolds its proboscis and inserts it down the corolla in order to tap the nectary. While the butterfly is thus engaged, it unconsciously conveys a few of the pollen-grains, gathered by its proboscis from the flowers visited just previously, to the stigma and thus causes cross-fertilization. While being withdrawn, the proboscis rubs against the pollen-sacs and gets coated with pollen-grains ready to be conveyed to the neighbouring flower.

In the orange-red variety of *Lantana camara*, the just open flowers are bright yellow and are different in colour from those a day or two older, which

vary from reddish-orange to crimson. The butterflies have been observed invariably to go straight to the yellow flowers and are apparently guided in their selection by the colour sense. There is a corresponding change of

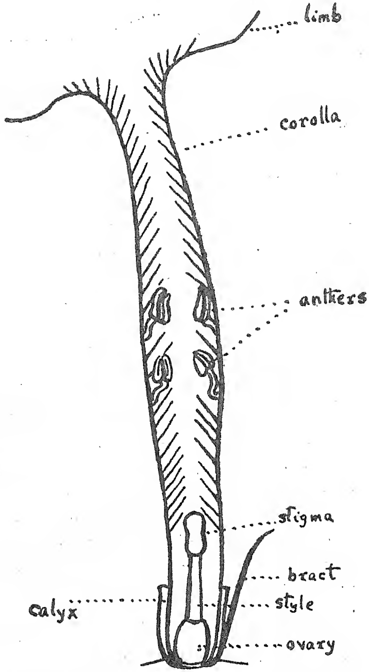


Fig. 3. Longitudinal section of a *Lantana* flower (×7).

colour between fresh blossoms and the spent ones also in the other varieties of *Lantana*, which undoubtedly serves as signboards to the butterfly-visitors.

Though largely favoured by butterflies, *Lantana* is visited by various other flower-frequenting insects, including bees, moths and a few flies.

The following are some of the insects actually noted visiting *Lantana* flowers :

BUTTERFLIES.—

1. *Papilio polymnestor.* Coorg.
2. *Papilio paris tamilana.* Coorg.
3. *Papilio helenus.* Coorg.
4. *Papilio agamemnon.* Coorg.
5. *Papilio sarpedon.* Coorg.
6. *Papilio polytes.* Coorg.
7. *Papilio demoleus.* Coimbatore.
8. *Papilio hector.* Coimbatore.
9. *Cirrhochroa thais.* Coorg.
10. *Cupha placida.* Coorg.
11. *Junonia hierta.* Coorg.
12. *Euplœa coreta.* Coorg.
13. *Hypolimnas misippus.* Coorg.
14. *Danais nilgiriensis.* Yercaud.
15. *Neptis eurynome.* Coorg.
16. *Delias eucharis* Coorg.
17. *Catopsilia pyranthe.* Coorg, Coimbatore.
18. *Curetis thetys.* Coorg.
19. *Yphthima huebneri.* Coorg.

MOTHS.—

20. *Cephonodes picus.* Coorg.
    and *Macroglossum* sp. Coonoor.
21. *Phytometra* (*Plusia*) *albostriata.* Shillong.
22. *Phytometra* (*Plusia*) *orichalcea.* Shillong.
    (21 & 22 were observed visiting *Lantana* flowers at dusk at Shillong in July 1918.)

HYMENOPTERA.—

23. *Apis dorsata.* Ramandrug, Bellary Dist.
24. *Crocisa emarginata.* Londa.
25. *Anthophora zonata.* Barapani (Khasi Hills).
26. *Ceratina hieroglyphica.* Coorg.

FLIES.—

27. *Eristalis* sp. Shillong.
28. *Coryzoneura* (*Pangonia*) *taprobanes:* Gudalur (Nilgiri Hills). This fly was found visiting flowers of *Stachytarpheta indica* in addition to those of *Lantana*.
29. *Thrips.* (2 species.) Throughout India.

At Gudalur (Nilgiris) a tiny bird, probably a species of sun-bird, was observed visiting flowers of *Lantana*, in September 1917.

In March 1917, when I first arrived in Coorg, the season was very dry. Though in some of the less moist parts of Coorg *Lantana* had absolutely dried up, it was quite green and altogether flourishing around Rockhill, near Sidapur.

There was quite an abundance of fruits and a fairly large quantity of flowers. Owing to the dryness of the season, very few insect-visitors were noticeable, there being a notable paucity of butterflies at the time. I was somewhat surprised to find that, in spite of the perceptible scarcity of the common run of insect-visitors, most of the flower-clusters were setting into fruits. An examination of the flowers, however, disclosed the fact that they were frequented by large numbers of Thrips and a detailed inspection indicated that these were actually functioning as agents in fertilization.

There were two different kinds of Thrips noticeable on *Lantana* flowers at the time of these observations. One was a black elongate species of the Sub-order Tubulifera. It was chiefly found living outside the flowerbuds and the flowers. The other, belonging to the Terebrantia, actually tenanted the interior of the corollas. The individuals were of two markedly different kinds, one being dark brown, almost blackish, and the other much smaller and pale yellow in colour. Examination under the microscope showed that the darker individuals were all females armed with a curved, saw-like ovipositor, and that the pale ones were all males. On a few occasions the pale individuals were actually noted courting the darker ones. The minute eggs were laid inside the tissues of the corolla and the young ones, on hatching, crawled about in the interior and fed on the pollen-grains and the nectar, as probably the adult ones also do. Under the microscope numerous instances of young larvæ carrying pollen-grains on their bodies were noted, and it is quite conceivable that they would, while moving down from the anthers to the nectary, deposit a few of the pollen-grains on the stigma, thus causing self-fertilization. It is also probable that the adults, which are able to migrate from flower to flower, carry pollen from one flower to another and thus bring

about cross-fertilization. In this connection, the observations (of the publication of which I was unaware till February 1919) made in America with regard to the prominent part taken by Thrips (*Thrips tabaci*, etc.) in the fertilization of Beet flowers, are of particular interest. (*Bull. U. S. A. Department of Agriculture No. 104*, by Harry B. Shaw).

In order to find out whether *Lantana* flowers can be fertilized by the agency of Thrips alone, the following experiments were devised.

On the 14th March, 1917, as a preliminary experiment, three twigs with unopen flower clusters were selected and enclosed in muslin bags. Before being enclosed, the flower buds were carefully examined to see that all Thrips were entirely excluded from them. In the case of one of the bags (Bag No. 3) adult Thrips collected from other flowers were introduced before being tied up, while the other two (Bags Nos. 1 and 2) remained free from Thrips. When examined on the 20th March, 1917, yellow dots, evidently composed of masses of pollen, were noted on the surface of muslin bag No. 2 at nine different places, in situations where the flowers were adjacent to the muslin, obviously indicating that the bag had received the attentions of a butterfly visitor. Such pollen-masses were not noticed in the case of the other two bags. When examined on the 31st March, 1917, the following results were noticeable.

Bag No.	Nature of experiment	Number of flower-cluster enclosed	REMARKS
1	Thrips eliminated	2	Only one fruit had set in each cluster. One of the two clusters had been attacked by the caterpillar of *Platyptilia pusillidactyla*.
2	Ditto	Several flower-heads	Only five (5) fruits were noted in all. A butterfly had evidently visited the flowers, inserting the proboscis through the muslin.
3	Thrips introduced	Several clusters	15, 17, 7 and 15 fruits had respectively set in 4 of the clusters, and in a fifth only 2 had set, the rest having been destroyed by the Plume-moth.

These preliminary experiments, though vitiated by the interference of the butterfly visitor, however, indicated sufficiently clearly that Thrips could function as important factors in the fertilization of *Lantana* flowers.

In continuation of these experiments, 10 twigs with unopen flower clusters at the tips were selected on the 5th April, 1917. As before, they were first thoroughly examined in order to free them from Thrips and the eggs of flower-feeding insects, and then enclosed by bags. In five of these, the factor of Thrips was entirely eliminated, while in the rest adult and young Thrips were

introduced, corollas containing the Thrips being bodily transferred in order to give them shelter, until the time when the enclosed flower-heads might open.

The bags were supported by an internal skeleton of brass-wire to prevent them from collapsing. Further, in order to prevent effectively the intervention of butterflies, the wire-skeleton was enclosed inside the bag by a cone of stiff-paper, on which notes regarding the experiments were also entered.

This set of experiments was, however, doomed to be a failure, as owing to the stormy and rainy weather that prevailed at Sidapur between the 7th and the 12th April, 1917, the open flowers both within the bags and outside on the bushes were shed off. Rents were also found in the muslin of some of the bags, owing to their becoming entangled among the *Lantana* prickles of neighbouring branches, when violently swayed about by the heavy winds. The results of these experiments were, therefore, of very little value and are not recorded.

A third set of experiments was taken on hand on the 16th April, 1917. From experience gained from the previous failures, a longer type of bag was adopted, so as to allow for the growth of the branch while enclosed in the bag and prevent the flowers from reaching the muslin cover at the apex. As before, 5 of the bags enclosed flower-heads which had been freed from Thrips, while in the other five Thrips were deliberately introduced. The results of these experiments are shown in the table given below :—

Thrips excluded.

Bag No.	No. of flower-cluster enclosed	Results of examination on 26th April, 1917, and remarks
15	Two flower-heads with unopen flowers.	None of the flowers set into fruits.
16	Ditto	The twig was found to have snapped in the middle and dried up.
17	Ditto	Except in one doubtful case none of the flowers set.
18	Two flower-heads (4 open flowers found in each were plucked off).	One of the flower-clusters had become damaged and had dried up, while in the other none of the flowers had set.
19	Two flower-clusters about to open.	One fruit had set in one cluster and none in the other.
	Thrips introduced.	
20	Two flower-heads	19 flowers had set in one cluster and 15 in the other.
21	One flower-head only ...	Only one fruit found: the flower-head had been attacked by *Platyptilia.*
22	Two young flower-heads ..	19 fruits in one bunch and 15 in the second.
23	Two young clusters ...	5 in one and 8 in the other.
24	Two very tender flower-heads	3 in one (attacked by *Platyptilia*) and 11 in the second.

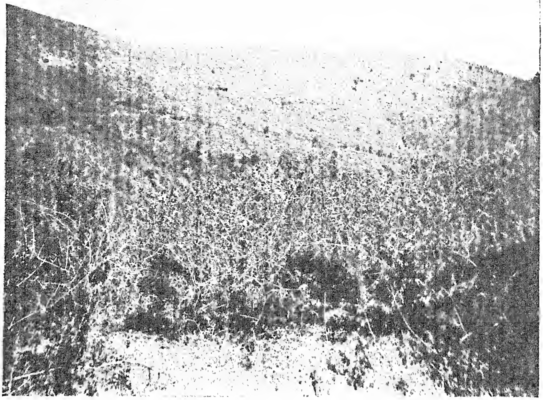


Fig. 1. Hill covered entirely with *Lantana*, Mercara, Coorg, May 1917.

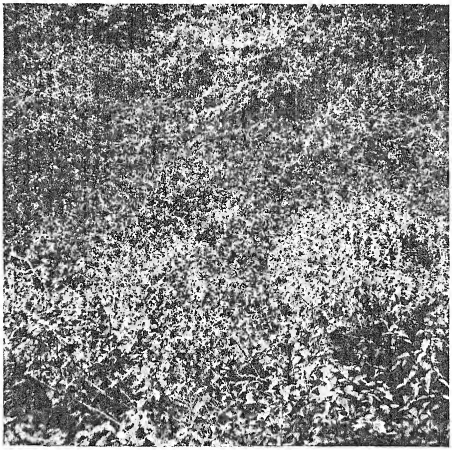


Fig. 2. Hillside covered with *Lantana* at Ramandrug, Bellary District, August 1918.

The results of the above experiments may be summed up roughly as follows :—Where Thrips had been eliminated, only two fruits had set out of seven healthy flower-clusters, whereas, when Thrips had been introduced, 96 fruits had set out of nine healthy flower-heads.

The results of the third set of bagging experiments may therefore be held to be fairly conclusive, though a sufficiently high degree of thoroughness has not been brought to bear on them. For instance, though muslin bags are fairly proof against the ingress of adult Thrips, they are powerless when young larvæ are concerned. In future experiments of this nature, the use of paper bags would seem to be imperative. There appears on the whole very little doubt that Thrips do act as important agents in the fertilization of *Lantana* flowers. In case the introduction of the Agromyzid be decided upon and in case *Lantana* plants with the Agromyzid breeding in the growing fruits are proposed to be brought alive in Wardian cases, Thrips may possibly prove useful in bringing about the fertilization of flowers within the Wardian cases.

5. THE *LANTANA* PROBLEM.

The real magnitude and gravity of the *Lantana* question cannot be appreciated properly until one has visited areas badly infested by the plant. In parts, like Coorg, where the conditions are favourable for its development, the extraordinary luxuriance of growth of *Lantana* is obtrusively evident to the onlooker and extensive stretches of *Lantana* wastes meet the eye on every side, covering hill-sides and filling up the hollows. Dense masses of the weed standing 8 to 10 feet high have taken the place of all low-growing vegetation which is smothered under its heavy shade. (Plates XXX, XXXI.)

Under the dense shade of heavy virgin forests it is usually unable to gain an entrance ; and when it does enter, it exhibits but a weak and lanky growth. The case is altered when a portion of the forest is felled and a clearing made. Before the seedlings of forest trees have had time to grow and fill up the blanks, the *Lantana*, that may already have been there or may have been freshly sown by birds, springs up and in a short time covers the area so thickly as entirely to choke up the saplings and suppress the seedlings. The rejuvenation of the jungle becomes in these cases a serious problem for the Forester. Moreover, the liability of *Lantana* to fierce forest fires renders its entry into the jungle a cause of grave danger, especially when it happens to be of a dry and deciduous character.

Again, owing to its steady encroachment into all open areas, pasture grounds have been becoming more and more limited year by year. The heaviest growth of *Lantana* is usually found in land once cultivated with

coffee but later on neglected and allowed to run to waste, and *Lantana* always exhibits a more luxuriant growth in soil loosened by cultivation because the roots are then able to penetrate it more freely. A dense growth of *Lantana* usually encompasses villages in the Malnad tract and owing to the cover thus offered gives room to the villagers to bring about various insanitary conditions, whereby epidemics like cholera are easily spread. At Chikalda in Berar a thick growth of *Lantana* around the station was believed to have been responsible for certain cases of diphtheria which occurred there in 1893.

Owing to the greater conservation of moisture brought about by extensive sheets of *Lantana* covering up the open places, free drainage of the surface soil is affected and has been considered to lead to an increase of malaria in the neighbourhood. The foliage gives shelter to multitudes of mosquitos and flies, while the large hollow spaces to be found beneath the thick canopy of the interlaced branches of a *Lantana* thicket provide a safe retreat to various noxious animals, such as jackals, porcupines, wild pigs and snakes, and occasionally also to a panther or two and perhaps even to the tiger.

In spite of such an array of evidence as to the injurious nature of *Lantana*, there is an opposite camp that holds that it is really a blessing in disguise. Many of the residents in Coorg, including planters, hold that it functions as an invaluable fertilizer, turning what were mere open wastes, unfit for any cultivation, into rich arable land on which any crop might be grown. By the dense cover it provides, they declare that it wards off the rays of the sun and prevents an undue evaporation of the soil-moisture, and its numerous surface roots are said to prevent soil erosion, while the large mass of shed leaves accumulating on the ground year by year is reported to turn into a rich and valuable humus. To reclaim *Lantana*-ridden land, one has only to cut the *Lantana* down, burn it when dry and then dig out the roots ; the land is then ready for any crop—tea, coffee, or rubber. Besides the humus in the soil, the *Lantana* ash, which is rich in potash, forms by itself a valuable manure, while the land is unquestionably cleared of all weeds and grasses. Under the above circumstances, they consider it a folly to think of eradicating *Lantana*, whereas in their opinion it would be wiser to endeavour to utilize its presence where possible and check its spread where necessary. This view is not confined to Coorg, but is supported by experience in various *Lantana*-infested countries in the Tropics, such as Hawaii, Java, Ceylon and parts of Australia. The general opinion in these islands is strong as to the soil-renovating and the soil-fertilizing properties of *Lantana*, while in an issue of the *Queensland Agricultural Journal*, September 1912 (p. 240) the following definite recommendation is made. "Exhausted sugar lands may

be worked up again, after lying idle for a few years and allowing *Lantana* to grow, which acts as a very valuable green manure crop, accumulating particularly large amounts of potash."

By some people *Lantana* is believed to be a good nurse to Sandal, while others appear to condemn it as the cause of spike in Coorg.

There, thus, seem to be very divergent views as to the economic status of *Lantana*.

Though the soil-fertilizing properties of *Lantana* are generally recognized, the quality of the humus, as compared with what is formed naturally in forests, has been questioned. While it is obvious, as Mr. McCarthy, Conservator of Forests, Coimbatore, stated, that it grows only in humid areas where even otherwise an indigenous vegetation would spontaneously spring up, it does not thrive in dry tracts like Coimbatore, where its soil-enriching powers would be of the greatest value, so that its much-vaunted qualities do not come into play where actually needed.

So far as its relations to deciduous forests are concerned, there would appear to be no doubt as to its injurious nature, and consequently considerable attention is devoted in many of the forests of India and Burma to the eradication of *Lantana,* wherever it has made its appearance.

Methods of eradication.

Neither the agriculturist nor even the planter is affected by the *Lantana* evil, for the few weedings and hoeings that even a careless cultivator will give to his crop are sufficient to keep *Lantana* out of his land. It is only when he neglects these operations continuously for a series of years that *Lantana* is able to take possession of the land, but, when he can command the means, he will always find it easy as well as paying to rid his field of the weed.

The *Lantana* infestation is a problem mainly affecting Forest areas and open waste-lands and grazing grounds. The problem has come into existence in all these cases only owing to the fact that the periodical removal of the plants in the early stages has not been attended to, in the *forest areas* because of the extensive areas concerned, and in the *grazing commons* because nobody in particular attends to them for the simple reason that they are common property.

Attempts have been made at various times to eradicate *Lantana* by mechanical means. People have endeavoured to cut it down and burn it, but have usually found to their sad experience that by the succeeding year a denser and more formidable growth of *Lantana* has sprung up in its place, for not only do the stems and main roots produce shoots in abundance but the

seeds that drop to the ground also get opportunities of germinating. Even when the stumps and roots are dug out, if the destruction of the seedlings that spring up is not attended to for a few years in succession, failure is sure to result.

The real reason of failure in all early attempts was the want of thoroughness in the methods. In Coorg, since 1912, Mr. H. Tireman, Conservator of Forests, Coorg, formulated a scheme which is being systematically followed in Coorg forests for ridding them of *Lantana*. The *Lantana* thickets are set fire to twice or even thrice in the summer during the first year. The stumps are dug out by coolies when the ground becomes soft during the Rains. During the second year, the area is again examined and all regrowth is uprooted and destroyed and at the same time the area is sown with seeds of forest trees. During the third and fourth years, the area is re-examined and all fresh growth of *Lantana* is again destroyed, and by the fifth year the canopy of the young forest trees is thick enough to suppress any regrowth of *Lantana*. The cost was reported to work out at about Rs. 8 or 9 per acre during the first year, R. 1-8-0 during the second year, R. 0-12-0 during the third year and R. 0-6-0 during the fourth. The method is reported to have been very successful.

Previous to the present operations in Coorg, eradication of *Lantana* on a large scale had been tried at Chikalda in the Melghat in Berar. On the plateau around Chikalda, the plant had originally been introduced about 1865 and had covered by 1890 the greater part of the tableland and had extended into the forests along the flanks. Control measures were undertaken in 1893, and between 1893 and 1904, Rs. 27,000 had been spent in uprooting *Lantana* in the Melghat Forests. In 1905, *Lantana* was considered to have ceased to be a trouble and operations were stopped. In 1911–13, however, attention was again devoted to clearing some areas where *Lantana* had again developed. When I examined the area recently, during my visit in January 1919, I found masses of *Lantana* still standing in parts of the forests along the road from Ghatang to Chikalda. Even on the plateau, where *Lantana* destruction had been paid greater attention to, plants were still noticeable in odd corners, growing undetected. This shows how difficult it is to attempt to exterminate *Lantana* in places where it has really overrun the land. Unless the eradication is done absolutely thoroughly and unless the entire area is vigilantly watched to guard against the re-entrance of the weed, all the work done is likely to prove to be labour wasted; for, if left alone, the conditions being the same, the plant is bound to become dominant once again and reassume the original pest conditions.

It is when this aspect of the question is considered that the superiority of the introduction of an efficient natural check over a mechanical method of eradication is forcibly brought to our minds, for the plant is thereby kept under check once and for all, obviating all recurring expenditure.

The importation of another plant to keep *Lantana* in check has been tried in Ceylon. Major Prain refers as follows (in a letter which was published in the *Indian Forester*, XXVII, p. 28), to "a sunflower, *Tithonia*, found in Ceylon where, when it runs wild, it replaces *Lantana*, but Ceylon planters look upon *Lantana* as a blessing and think nothing has done so much to renovate abandoned coffee land, while the sunflower is more difficult to eradicate and exhausts the soil".

Messrs. Tryon and Johnston in their *Report of the Prickly Pear Travelling Commission* mention (page 2) that "Dr. Konigsberger pointed out a peculiar natural enemy of *Lantana*, that occurred in Sumatra, at Deli, and suggested that the occurrence might yield a new outlook in connection with the work. This was a weed belonging to the composite genus *Eupatoria*, which grew with great vigour and literally choked the plant in question". The plant referred to is probably *Eupatorium odoratum*, an account of whose occurrence and alarming spread in Burma and Assam is given under the heading of "other pestilential weeds"; and there is no doubt that, if this be the plant, the remedy is certain to prove worse than the disease itself.

The introduction of the *Lantana* seedfly is a method that is reported to have been successfully tried first in Hawaii and later on in New Caledonia, Fiji and lastly in Queensland. It has been claimed that this method, while not encompassing the destruction of the plant, is definitely able to check its spread and render it possible for one to clear *Lantana*-covered land once and for all without the fear of having to repeat the work every few years.

6. DISTRIBUTION OF *LANTANA*.

(*a*) Factors controlling the Distribution of *Lantana* in India.

Before dealing with the present distribution of *Lantana* in India, the factors which have controlled its spread into the various parts of India may be considered. It has invariably been introduced as a garden plant and, owing to the ease with which it can be propagated by cuttings, has been later on utilized for planting as a live fence around bungalows. Invariably, the starting point has been the city or the big town. From these centres *Lantana* has passed by stages into the country, being carried by visitors from the villages.

In Coorg, it is reported that, in the early days of its arrival, salesmen made a roaring trade by the sale of cuttings, and the countrypeople were said to have clandestinely taken cuttings overnight from the hedges at Mercara and carried them over to their villages. Railway platforms have in many cases, as for instance on the Amritsar-Pathankot Branch, served as nuclei from which the plant has spread. Banks of irrigation canals have in some cases served a similar purpose.

While there are a good many varieties of *Lantana*, which are absolutely sterile or at least produce few fruits, the plant as a general rule seeds extraordinarily profusely. The fruits being edible are eagerly devoured by birds and spread broadcast over the country along with their droppings. Where the climatic conditions are favourable, the *Lantana* seedlings spring up in profusion and by reason of their high vitality soon crowd out all other low-growing vegetation, and form the extremely dense thickets which are common in badly infested parts like Coorg.

Lantana would appear to thrive best only when certain conditions are fulfilled.

The first requisite would appear to be the presence of a large amount of moisture in the soil as well as in the atmosphere. It flourishes well in areas receiving a rainfall ranging from 50 to 150 inches. Very heavy rainfall appears to be prejudicial to its growth, as is evidenced by the paucity of the plants in the *ghat* region in Coorg and at Cherrapunji on the Khasi Hills. Along the long line of the Western Ghats its distribution is extremely interesting. While the low-lying West Coast receives 100–140 inches of rain during the year, the crest of the abruptly rising *ghats* is subject to a rainfall ranging from 150 to 250 inches. On its eastern flanks, the rainfall rapidly falls away and gradually decreases from West to East in the neighbouring uplands of Coorg, the Wynaad, and Malnad. For instance, in Coorg, while near Mercara it approximates 140 inches, at Sidapur it is only 90 inches, and near the Mysore borders it dwindles down to about 40 inches. In the semi-arid tracts of Mysore the rainfall is only 25–30 inches, while in the dry central districts of the Deccan it is barely 20. The relative abundance of *Lantana* closely follows the distribution of the rainfall. While it is most abundant in Coorg, the Wynaad and Malnad with moderately heavy precipitation of rain, in the semi-arid region of the open plateau of Mysore *Lantana* growth is restricted mostly to isolated and stunted bushes spread over the country, and in the arid tracts of Gadag and Bellary it is practically absent.

A similar instance is seen in the distribution in the Punjab. While it is abundant in the submontane districts with 30 to 100 inches of rain, as at

Gurdaspur, Pathankot, etc., *Lantana* is altogether rare in the arid plains of the Central Punjab.

In dry districts, the only places where *Lantana* may be found growing are in moist situations, as around the banks of canals and the margins of tanks and wet-land areas.

The *next desideratum* would appear to be a well-drained soil, a water-logged one being prejudicial to its growth. A striking instance is furnished by a study of the relative distribution of *Lantana* in the Bhabar and the Terai tracts near Haldwani in the United Provinces. "*Bhabar*" (lit. porous) is the name given to a narrow strip of country about 10 miles broad, stretching along the foot of the Himalayas in Kumaon. The soil is composed mostly of fine earth mixed with stone and gravel, forming part of the *debris* washed out when the uplift of the mighty Himalayan Range occurred. The soil is extremely porous and all the water drained out from the hillsides is reported to sink to an unknown depth and re-emerge as natural springs in the low marshy tract of the "*Terai*" lower down. Whereas the "*Bhabar*" is extremely well-drained, indeed to such an extent that wells are unknown in this tract, the "*Terai*" is completely water-logged.

In the "*Bhabar*", inadvertently introduced at Kathgodam about 30 years ago by an Engineer, it has spread through the country like wildfire, entering the jungle, and invading pasture-grounds and open waste-lands; whereas in the "*Terai*" comparatively small quantities are to be seen in favourable situations, and apparently *Lantana* has no chance at all of spreading in that marshy jungle, the home of the tiger and tall giant grasses.

In Coorg, again, it is only the well-drained slopes of the hills and the ridges that are *Lantana*-ridden, while it is scarce in the marshy hollows lower down.

Thirdly, *Lantana* does not seem to be able to bear great extremes of temperature. Frost and snow as well as dry scorching heat appear to be inimical to its growth. On the Nilgiris, the growth of *Lantana* stops at a height of about 6,400 ft.; at altitudes of 7,000 ft., as at Ootacamund, subject to frosts, it is practically absent. It is reported that *Lantana* has spread into the Chamba valley in the Punjab Himalayas, where snowfall would appear to be common, but I have no idea of the actual conditions, as I had no opportunity of visiting it.

Lastly, *Lantana* is a lover of sunshine, though not of too much of it. Shade is prejudicial to its growth and it has absolutely no chance of thriving under the leaf canopy of thick forests. When, however, a clearing is made in the forest, *Lantana* quickly occupies the open spaces and prevents its natural regeneration.

(b) Distribution of *Lantana* in India and Burma.

South India.

As regards the distribution of *Lantana*, Southern India may be divided roughly into three distinct regions :—

1. *The Western Ghats region*
2. *The Central region* consisting of the Mysore Plateau and detached hills like the Shevaroys, Ramandrug Hills, etc.
3. *The East Coast Littoral.*

1. *The Western Ghats region* is by far the most important of all. The Western Ghats are a very long chain of Hills, extending north to south for nearly 1,000 miles from Khandesh to Cape Comorin. The range varies in height from 2,000 to almost 8,000 ft. and generally rises abruptly from the lowlands of the West Coast. Along its eastern flank, the range slopes more or less gradually until it merges into the plateaus of the Deccan, Mysore and the Nilgiris. South of the Palghat gap there is, even on the Eastern flank, a sudden drop from a height of 3,000 ft. or more to the lowlying plains of the southern districts of Madras. *Lantana* is noticeable in abundance all over the lowlands of the West Coast and increases as the foot of the hills is reached, but on the steep western face of the range and along the elevated crests, fully exposed to the influence of the monsoon currents, very little of *Lantana* is to be found. Due partly to the heaviness of the rainfall and partly to the presence of evergreen forests, *Lantana* does not appear to spread there.

To the north of the Nilgiri Hills, there extends, along the eastern flank of the Western Ghats, a distinct belt of heavily wooded, upland area, consisting of a confused tangle of ridges and hollows, which includes the Province of Coorg, the Wynaad taluq of Malabar, the Gudalur taluq of the Nilgiris, and the tract known as "Malnad" (lit. hilly country) in Mysore and South Bombay (Plates XXX, XXXI). It is in this area that *Lantana* attains its heaviest developments and is seen at its worst. It is also in this tract that the problem of *Lantana* control is felt the keenest and its solution is of supreme importance. As the "Malnad" gradually passes into the open uplands of Mysore, *Lantana* also becomes less and less abundant, until at last in the open country only isolated stunted clumps are seen.

The Nilgiris. Where *Lantana* has been able to effect an entry, it is noticeable in abundance below an altitude of about 5,000 ft.; 3,000-4,000 ft. appears to be the optimum height for it in the Nilgiris, as is evidenced by the quantities found around Gudalur and Hillgrove and Runnymede. A heavy growth is

also noticeable at Kallar, at the foot of the hills. At Coonoor, large masses are observable, but as one travels higher up the plateau, *Lantana* is noticed to become less and less abundant, until at some distance above Aravankad (6,200 ft.) it entirely disappears. *Lantana* is absent at Lovedale and Ootacamund (where the only representative is a pink plant struggling for existence in the Botanical Garden).

At Kotagiri (6,500 ft.) only three straggling plants were found after much search, but three miles lower down along the Mettupalayam Ghat Road, *Lantana* begins to appear and is found increasing in abundance as one travels down. Along the Ootacamund-Gudalur Road, the first specimen of *Lantana* is noticed near Naduvattam (6,000 ft.). It becomes plentiful below an elevation of 5,000 ft. While on the plateau the red and the pink varieties are both present, along the flanks the red one greatly predominates.

The Anamalais. The Anamalais are a confused mass of hills, rising abruptly from the plains of the Coimbatore District and breaking up westwards into high ranges and deep valleys, all clad with heavy primeval forest. The lower elevations are covered with valuable forest, containing teak, rosewood, bamboo, etc., while the higher altitudes contain magnificent evergreen or "*Shola*" forest. A great part of this "*Shola*" forest has been cleared of recent years and planted with tea, coffee and cardamoms.

In the teak forest area around Mount-Stuart, *Lantana* was plentiful chiefly along the sides of the forest tramline but even in the interior of the forests numerous plants were noticeable, showing, however, only poor and lanky growth for want of sunshine. On the Punachi side of the Anamalai Hills, *Lantana* was on the whole rather scarce, but in a portion of the tea forest area about two miles from Attakatti, it was extremely abundant, being reported to have migrated from the adjoining Waterfall Estate, in which *Lantana* had been cultivated as a hedge-plant and where large fences still line the cart-road. Further up, in the interior of the Anamalai Hills, *Lantana* was noticed only around Iyerpadi, no trace of the plant being noticeable anywhere else in the planted area.

I have had no opportunities of examining the Western Ghats region, south of the Anamalais, but from information derived from the Forest Department, *Lantana* would appear to be plentiful on the Palni Hills, and around Ambasamudram and Srivilliputur, and on the Courtallam Hills in the Tinnevelly District.

2. *The Central Region.* *Lantana* is common throughout the State of Mysore, though it is only in favourable situations, as for example around Tumkur, that it shows an extraordinary luxuriance of growth.

In Bangalore it is a common and favourite hedge plant and is also commonly noticeable in waste-lands as an escape from cultivation.

At Horsleykonda—4,100 ft.—in the Chittoor District, masses of *Lantana* are reported to be noticeable.

On the Shevaroy Hills, in the Salem District, *Lantana* is reported to have been introduced about thirty years ago by Mr. Dixon Carter as a rare garden plant from Bangalore. Since then it has gradually spread until at the present time it has become so common that it is difficult to find an open place unoccupied by it anywhere around Yercaud. Fortunately, however, *Lantana* is at present noticeable only for a few miles around Yercaud, and several places such as Nagalur, Vallakadai and Kaveri Peak are still free from it, and coffee-planters in these places are vigilantly guarding against its introduction into their area. It is the pink variety that has spread around Yercaud, but the red one is also noticeable a few miles off.

Ramandrug is a small Hill Station, 3,500 ft. high, situated on a narrow plateau on the crest of the Sandur Range in the Bellary District. About forty or fifty years ago *Lantana* appears to have been introduced as a rare hedge plant from Bangalore and planted around one of the bungalows. Since then it gradually and imperceptibly increased, till it spread into the forest and covered extensive areas on the tops and sides of the hills (Plate XXXI, fig. 2). Though the dominant variety is the red one, pink, yellow and mauve varieties are also observable.

Near Erode, the red variety of *Lantana* was found growing in some abundance along both sides of the railway embankment towards the Cauveri Bridge.

3. *The East Coast littoral.* The only area on the east coast that was examined by me was the tract around Madras. It is the pink variety chiefly that is noticeable in this area and is observable in fair abundance along the banks of the Buckingham Canal, along the sea beach in places and along lanes in Nungambaukum and Mylapore. *Lantana* appears also to have extended some miles to the south and the west along the railway lines. Being situated in an area subject to the heavy rains of the North-East monsoon, Madras appears to be an area favourable to the growth of *Lantana.*

Chicacole Road was the only other place where I noticed *Lantana* along the line of the East Coast Railway.

Travancore, Cochin, the Palni Hills, the Courtallam Hills and Hyderabad are some of the tracts that I had no time to visit.

Bombay.

Dharwar, Londa and Castlerock were the only places visited by me in the Bombay Presidency, but *Lantana* would appear to be present in

great abundance around Belgaum and Poona. I have noticed it growing in some quantity at Lonavla, Igatpuri and Nasik Road along the Railway line and in the neighbourhood of Bombay. Mr. T. N. Jhaveri, Entomological Assistant, Bombay, informed me that *Lantana* hedges are common at Surat and Baroda.

Owing to want of time, a visit to some of these places in Bombay had to be dropped out of the programme.

Dharwar is only on the fringe of the rainy "*Malnad*" tract and *Lantana*, therefore, occurs as scattered stunted bushes in open areas : but it grows into dense thickets in favourable situations such as around irrigation reservoirs and margins of streams. To the west of Dharwar, *Lantana* increases in quantity and masses of the plant are noticeable near Kambarkanve and at Londa.

Castlerock is a small station, 2,000 ft. high, situated in the very rainy Ghat region on the borders of the Portuguese territory, and in this place *Lantana* was absolutely non-existent, though it was very abundant at Londa only 16 miles away from Castlerock. *Lantana* was not noticeable also along the West Coast line from Castlerock up to Sanvordem.

A few plants were noted at Gadag station in the arid black soil tract east of Dharwar.

Burma.

Lantana appears to be, on the whole, a recent introduction in Burma, though at Rangoon itself it must have been existing for the last forty years at the least.

Though largely supplemented by personal observations, much of the information regarding the local distribution of *Lantana* in Burma was derived from the files of the Forest Department, for which I am much indebted to Mr. C. G. Rogers, Chief Conservator of Forests, Burma.

(1) *North Burma.* *Lantana* appears to be confined to gardens in private compounds and the heavy teak forests are quite free from this weed.

(2) *Central Burma and the Shan States.—Pyinmana.* Though found in some quantity on the dry gravel ridges found within municipal limits of the town, *Lantana* has not entered the teak forests close by, being separated from them by stretches of rice cultivation.

Lantana bushes were, however, noticeable along the Railway line, for some dense thickets were noted around the Railway Stations at Swa and Kyadaunggon.

Mandalay. Confined to gardens.

Maymyo. Found extensively cultivated as a live fence around bungalows in this Hill Station. It has escaped from control at Anisakan about 10 miles from Maymyo. (Plate XXXII, fig. 1.)

Lashio. Found grown as a fence around many of the bungalows and showing tendencies of escaping from control.

Kalaw (Southern Shan States). None noted, but *Lantana* was reported to have been seen in some of the Shan villages. I was informed by Mr. Wright, Forest Officer at Kalaw, that *Lantana* had been noted in the fruit gardens about six years ago at Loi-An, but had been destroyed since then.

(3) *Tenasserim Forest Circle.* Reported to be very bad in the neighbourhood of Pyu in Toungoo Division and appears to be spreading from the railway up and down the main floating streams.

At Moulmein, *Lantana* was noticed spreading along the sides of the ridge, close to the precincts of the Chief Pagoda there ; a few plants were noted also around an old Buddhist monastery.

Masses of *Lantana* were also reported to be noticeable at Tavoy.

(4) *Pegu Forest Circle.* (Pegu, Henzada and Arakan.)

Pegu. *Lantana* was found growing among hedges around Bungalows.

Rangoon. Chiefly noted grown as a live fence, though in some places it was noticed as an escape from cultivation. Noted also at Insein and along part of Railway line to Prome.

Henzada. A small quantity was reported from unclassed forests in that Division.

Arakan. According to Mr. Rogers, "The lilac-coloured *Lantana* was introduced into Paletwa in the North Arakan Hill Districts, about 20 years ago, by the Deputy Commissioner, Mr. W. Hildebrand. It has spread a good deal on the cleared hills around the station and has also found its way down the Kaladan River, where it is fairly common in the forest near the River."

Also known to be abundant at Akyab.

Information regarding the existence of *Lantana* in Arakan and at Pyu was obtained rather late and I could not find time to visit these areas. Besides these two, the only places where *Lantana* was found in abundance and where there was real danger of spreading was around Maymyo and Anisakan.

At Maymyo a veritable craze for *Lantana* fences was noticeable. On every side and in every lane *Lantana* meets the eye. The fences were extremely pretty, being composed of several distinct varieties bearing flowers that offered a striking contrast in their colours. It was however clear that it was only the orange-red variety that seeded profusely and on that account was the only really harmful one. The others were either absolutely sterile or

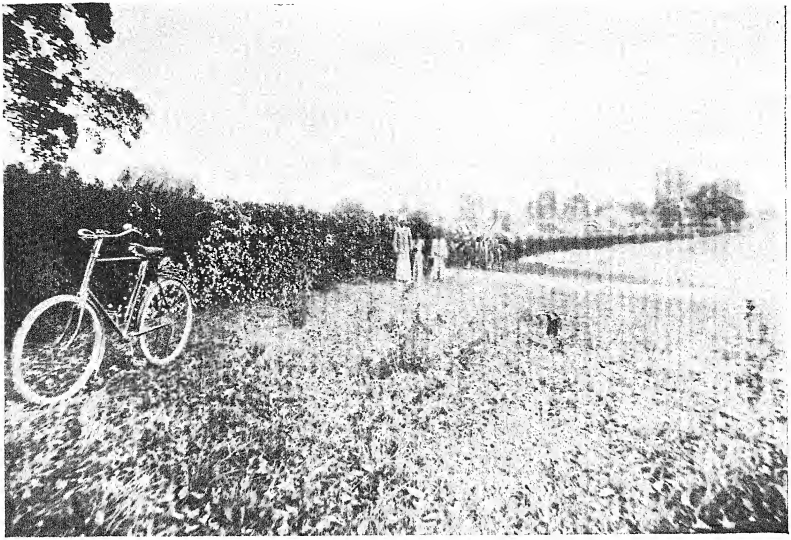


Fig. 1. *Lantana* hedge bordering compound of Club at Maymyo, Burma, April 1918.

Fig. 2. *Lantana* covering a slope at Dehra Dun.

produced fruits very sparingly. Mr. C. G. Rogers, Chief Conservator of Forests, was of opinion that there was not much danger in *Lantana* hedges if they could be properly clipped at intervals, for it was only when they were neglected that they ran to seed and become a source of danger. From inquiries made, *Lantana* appears to have been introduced into Maymyo about twenty years ago, but considering the length of time it has been there, it is rather amazing that it has not spread more widely than it has done actually. It is plain, however, that it has escaped into the open and entered the outskirts of the jungle, but evidently it has not yet assumed the dimensions of a pest. At Anisakan, only a few miles off, on the other hand, though introduced only 10 or 12 years previously, it has already assumed a seriously aggressive form and shows a very vigorous growth. According to Mr. C. Dixie Kiernander, who is farming in that area, this luxuriance of growth is attributable to the effects of the desultory cultivation of the Shan tribes, who, following very primitive methods, burn a piece of the jungle, dig out the roots of trees, and after ploughing and reploughing the land, raise crops of paddy, sesamum, beans, potatoes and pine-apple in the course of two years, only to leave it fallow for the next seven or eight years. The soil, having been thoroughly loosened in this manner, has proved a happy nursery for *Lantana* escapes.

Assam.

For information regarding the distribution of *Lantana* in Assam, I am indebted to Messrs. Tottenham and Blunt, Conservators of Forests, Eastern and Western Circles respectively, and to Rai Bahadur Upendranath Kanjilal, Retired Extra Deputy Conservator, to whom my thanks are also due for his kindness in naming numerous plants collected in Shillong.

Lantana appears to be at present scattered in small patches throughout Assam, both on the Hills and in the valleys of the Brahmaputra and the Surma. It is, however, on the Khasi Hills around Shillong that it is found in largest quantity.

Sibsagar. Reported to occur sporadically throughout the Division and not yet to be a menace to forests as it chiefly occurs in old cultivation.

North-East Frontier. *Lantana* not common.*

Nowgong. Not plentiful.

Lakhimpur. Found scattered, not plentiful.

Sylhet. Found in some quantity.

Kamrup. Large patches of *Lantana* were seen along the Railway line and in the town at Gauhati.

* It occurs plentifully around Dibrugarh and at Margherita, but does not seem to have reached Dum-Duma or Sadiya. [T. B. F.]

Khasi and Jaintia Hills. Found in quantity in several villages around Shillong. Large patches of *Lantana* were noticed by me at Barapani, 9 miles below Shillong, and larger sheets of the same two miles further down the road to Gauhati.

Small patches of *Lantana* were found also at Cherrapunji, some on sites of old houses ruined by the earthquake; but, owing to the incessant rains, *Lantana* does not appear to be flourishing there.

At Shillong efforts seem to have been made since 1906 to keep *Lantana* in check, and within the limits of the Municipality destruction of *Lantana* in compounds has been made compulsory by law. In spite of these attempts to check it, *Lantana* is still to be found in fairly good numbers on hill sides and under pine trees.

In Assam, I was able to visit only Shillong, Gauhati and Cherrapunji. The rest of the province could not be examined for want of time.

Bengal.

Prain in his "Bengal Plants" remarks that *Lantana camara* occurs in the Central and Eastern portions frequently and in the Western portions only occasionally naturalized.

With the exception of Calcutta, I have not had the opportunity of visiting any part of Bengal, but in the following places *Lantana* was found in plenty along the Railway line from Howrah to Mokameh.

(1) Around Madhupur Railway Station, (2) Around Raniganj Railway Station, and (3) numerous *Lantana* bushes were noticeable along the E. I. R. line between the 9th and the 16th miles-stones from Howrah.

Lantana was noted cultivated in some of the gardens at Calcutta.

Bihar and Orissa.

Pusa was the only place examined by me in this Province.

A few *Lantana* plants are noticeable near the Pusa village growing in odd corners of uncultivated land.

Chota Nagpur. According to the *Forest Flora of Chota Nagpur*, *Lantana* occurs occasionally semi-naturalized in Chota Nagpur, as for example around Chorparan.

Orissa. *Lantana* hedges are reported to be common at Cuttack.

The Punjab.

Mr. R. N. Parker in his *Forest Flora of the Punjab, Hazara and Delhi*, makes the following remarks :—"It has obtained a footing near Madhopur,

Chamba and Sabathu, and is often seen in hedges in the Palampur Tahsil, Kangra District, and in Hoshiarpur. The plant has become a pest in parts of the Deccan and much has been written against it. In places which suit it, it grows in dense impenetrable thickets. If it could be got to grow in the Hoshiarpur Siwaliks or in the sheltered ravines of the Pabbi Hills, it would be very useful. In cultivated plants, flowers of all colours from cream to yellow, crimson and purple are found and the colour is frequently variable in the same head. Flowers more or less throughout the year."

Along the Amritsar-Pathankote line, *Lantana* was noticeable around the following stations:—Dhariwal, Sohal, Gurdaspur, Dinanagar, Sarna and Pathankote. At Gurdaspur, *Lantana* was noted growing as a hedge around several of the bungalows. Around the Railway Station at Sarna, very dense patches of *Lantana* were noticeable and it is evident that the platform gardens have along this line served as nuclei from which the weed has spread all round. Madhopur is a small village, 9 miles from Pathankote, whence the Ravi Canal commences. The sides of the canal and especially an elevated patch of waste land to the right of the canal road are covered by impenetrable thickets of *Lantana*. *Lantana* was found plentiful along the canal road as far down as Sujanpur (4 miles off), whence the road branches off to Pathankote. Whereas at Gurdaspur and Sarna, the red variety of *Lantana* was the commonest, it was entirely replaced around Sujanpur and Madhopur by varieties bearing pink, yellow and mauve-coloured flowers. The soil at Madhopur was a porous gravel composed of shingles and detritus washed down from the neighbouring hills and the nature of the soil in combination with a heavy rainfall has conduced to the development of a heavy growth of *Lantana*.

Lantana was common as a hedge-plant around compounds and fields at Hoshiarpur, where escapes in fairly large numbers were noticeable in waste-lands and around neglected hedges. At Amritsar, a few plants were noted growing around some of the fruit gardens, and at Lahore the only specimens of *Lantana* that could be found were certain ornamental varieties grown in Public Gardens.

Mr. G. R. Dutt, who worked in the Punjab during my absence on leave, examined Sialkot and Jhelum but did not find any *Lantana* growing wild in those places.

It was unfortunate that Palampur in the Kangra Valley and Chamba had to be left out on account of want of time, as a study of *Lantana* growth in such mountainous situations, where the climatic and physical conditions are so peculiar, would have been of great interest.

Owing to the extreme dryness of the climate, *Lantana* is very unlikely to spread in the plains of the Punjab, but in sub-montane tracts along the foot of the Hills receiving a good rainfall there are great possibilities of its assuming the status of a serious pest.

United Provinces.

The following information regarding the distribution of *Lantana* in the United Provinces was obtained at the Forest Research Institute, Dehra Dun.

"*Lantana* present in masses around Haldwani in Terai and Bhabar Government Estates."

"Found either cultivated or spreading as a weed in Lucknow, Jhansi, Lalitpur, Cawnpur, Gorakhpur and Kalpi."

The following places were visited by me in the United Provinces :— Dehra Dun, Masuri, Kathgodam, Haldwani, Nainital, Lucknow, Gorakhpur and Cawnpur.

Both at Dehra Dun and at Kathgodam, the soil, being formed mostly of detritus washed from the hills, is very porous, and owing to their situation at the foot of the outer Himalayas, these places are subject to a heavy rainfall (125 inches being received at Dehra Dun). The conditions are therefore very favourable for the spread of *Lantana*.

At Dehra Dun, *Lantana* hedges composed of several different varieties were noticed around some of the compounds ; *Lantana* was also noted spreading along the banks and sometimes in the dry beds of some of the *nallahs* in the neighbourhood. Especially was this the case in the case of one of the large dry water-courses known as the Rispana *nallah*, on the eastern bank of which numbers of self-sown seedlings of *Lantana* were observed growing under the shade of young mango trees in neglected plantations. (Plate XXXII, fig. 2.)

Kathgodam and Haldwani, which are only 4 miles apart, are both situated in a tract of country known as the *Bhabar* (lit. porous), which, as already explained, is composed of gravelly soils and is extremely well-drained. All the rain-water washed from the hills is reported to sink to an unknown depth and to be completely absorbed. The soil is so porous that wells are unknown in this area. *Lantana* is reported to have been introduced into this tract about thirty years ago by Mr. Doherty of the P. W. Department, in charge of the canals. First planted round his garden, step by step it spread all round until at the present day it is found occupying most of the waste-lands and the pasture grounds and large portions of the jungle. Near Kathgodam, dense thickets of *Lantana* were noticeable at the very base of the hills, up the sides of which also they were noted to extend for some distance. (Plate XXXIII.)

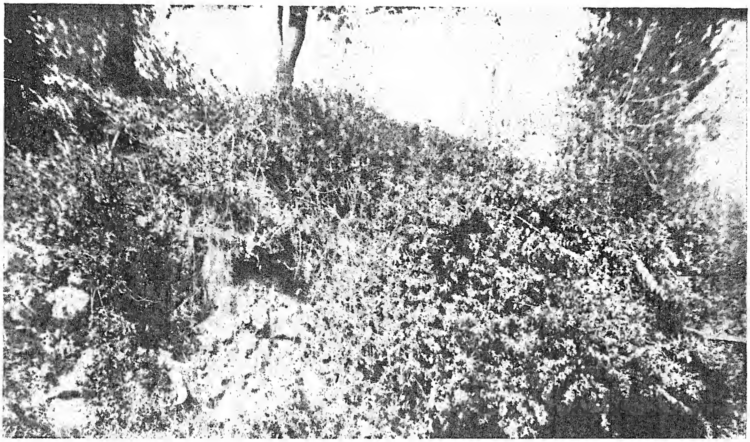


Fig. 1. Side of canal at Kathgodam, U. P., covered with *Lantana*, December 1918. Note the stony nature of the soil.

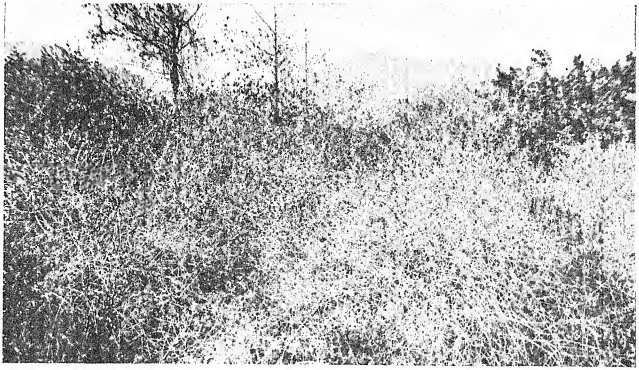


Fig. 2. Waste land overgrown with *Lantana* at Kathgodam, December 1918.

Along the Kathgodam-Nainital Road, *Lantana* was noted in good quantity for a distance of two miles, beyond which it was not noticed, though a mile nearer the Brewery a few stray plants were found by the road-side. *Lantana* was not noticed at Nainital, but it was reported that at Almora, about thirty miles farther into the interior of the hills, it was known to exist. Around Haldwani, it was the orange-red variety that had run *amok*, though pink-flowered bushes were also noticeable among the hedges.

In the Terai area, further down, which is badly water-logged and covered by giant grasses, *Lantana* is noticed in very much smaller numbers, some patches being noticeable near the Railway Stations of Lal-kuah and Kichcha.

Lucknow. Masses of *Lantana* were noticeable on both sides of the O. and R. Railway line bordering the cantonment. Here the land is undulating and broken up into rounded slopes and small water-courses. Originally planted around some of the compounds, it has strayed into this favourable well-drained area and has grown into dense thickets.

Gorakhpur. Being part of a moist and lowly situated area liable to floods, Gorakhpur is not a likely place where *Lantana* could spread. However, in several parts of the town, *Lantana* hedges are common and in one of the public parks *Lantana* was found growing freely on rockeries and small embankments ; and stray seedlings were observed under the shade of trees in the Park as well as in the immediate neighbourhood. The *Sal* forests in the vicinity were examined but are evidently too dense to allow of the intrusion of *Lantana.*

Cawnpur. As at Lucknow, *Lantana* was found running wild in somewhat undulating land, as for instance at Nawabganj, where it was noticed forming thickets in neglected garden compounds and in sparse jungle. It was also noted running wild in compounds in the city. It was rather remarkable that even in public gardens, *Lantana* was being allowed to flourish as if it were a rare ornamental plant, in spite of the fact that the plants were seeding profusely.

The B. B. & C. I. line from Cawnpur to Agra was, at the suggestion of Mr. Leake, Principal, Cawnpur Agricultural College, examined as far as Dariaoganj. *Lantana* was observed growing on either side of the Railway line up to Maudhana. Masses of *Lantana* were noticeable around the following stations : Rawalpindi, Kalianpur, Chaubepur, Bilhaur, Fatehgarh, Kaimganj and Rudain and in special abundance at Maudhana and Dariaoganj. At Dariaoganj where inquiries were made, it was reported that *Lantana* had been introduced about sixteen years ago as a live fence around the platform. The soil around the station is a sandy loam, favourable for *Lantana* and, owing to the abundance of birds, which were found greedily feeding on the fruits, the

plant has become rapidly disseminated and is now abundant all around the station for a distance of a mile. Here is a second instance of a Railway line being the starting point for the spread of *Lantana*.

The Central Provinces.

The following notes regarding the distribution of *Lantana camara* are found in Witt's *Descriptive Botanical List, North and Berar Forest Circles, Central Provinces*:—

"Common in the upper slopes of the Melghat; hilly localities in Buldana; waste-land near villages—Nimar (Chanda); not uncommon as a hedge—Saugor, Jabbalpur, Hoshangabad (Pachmarhi)."

Jabbalpur, Nagpur, Ellichpur and Chikalda in Melghat were the only places visited in the Central Provinces.

Jabbalpur. With the exception of a few stray plants growing among the hedges in the town, *Lantana* is non-existent at Jabbalpur.

Nagpur. *Lantana* of the pink variety was noted in some quantity growing wild around the Maharajbagh Farm and along the sides of the *nallah* running through the Park. Hedges were also found along the Railway embankment near the station.

Ellichpur. The red variety was noted in hedges around some of the fields and also on the sides of the large water-course running through the town.

Chikalda and Melghat. I am indebted for much of the information regarding the distribution and spread of *Lantana* in Melghat to office notes by Mr. Kenny, Deputy Conservator of Forests, Amraoti, whom, however, I could not meet personally.

Chikalda is a small hill station, situated on the top of a plateau, 3,500 ft. high, belonging to the Mahadeo Range of the Satpura Hills; it is also the chief town of the Melghat Taluq, and the summer headquarters of the Commissioner of Berar. *Lantana* appears to have been introduced about 1865 as a garden plant and planted as a hedge around bungalows and along roads and lanes, at Chikalda. Later on, it is reported to have been carried into the villages by the *gaolis* and by the Forest subordinates, and also to have been planted as a border fence along the newly constructed Ghatang-Chikalda Ghat Road about 1882. *Lantana* flourished exceedingly and rapidly encroached on the ground it was planted to protect, and through the agency of birds, it got distributed throughout the plateau and penetrated deep into the forests.

"In the early nineties," in the words of Mr. Kenny, "it is understood that much of the plateau was overgrown. This was undesirable from a sanitary point of view and is believed to have been responsible for certain cases of

diphtheria which occurred about 1892-93. At the same time, the dense growth in the ravines near Chikalda was found to have overtopped the natural trees, many of which were completely suppressed. It was decided that *Lantana* should be got rid of and work was started in 1893-94"

About 28,000 Rupees appear to have been spent towards the eradication of *Lantana* in the forests, between 1893 and 1905 and between 1911-1913.

According to Mr. Kenny, "*Lantana* has spread a good deal and is now fairly common in a great part of Sembadoh and in the Kharda and Khalsa villages and also around Hatra. It is to be seen everywhere in Chikalda range and in the eastern part of Gugumal. Much or most of the dense growth is found in forest which contains little teak. No serious damage to valuable forest is now taking place and it is unlikely that any regular operations will be found necessary."

I found a good deal of *Lantana* growing scattered in open places and also in the jungle all along the road from Ghatang to Chikalda. In favourable situations, as in moist depressions and along sides of ravines, masses of *Lantana* were noticeable. Even on the top of the plateau, where *Lantana* destruction had been carefully attended to, plants were noticed growing undetected in odd corners.

7. INSECTS FOUND ATTACKING *LANTANA* IN INDIA.

(*a*) Conditions under which the Inquiry was conducted.

The object of the present deputation was, in the words of the orders of the Government of India "an inquiry into the efficiency of the existing indigenous pests as a check on the spread of *Lantana* in India."

If any really effective insect enemies had already become evolved in any part of India, the fact would have been of such importance to people in areas infested by *Lantana*, that it would hardly have failed to attract their notice. The quickness, for instance, with which the fact of the outbreak of *Orthezia insignis*, the "*Lantana* Bug," in 1894 in Ceylon, and recently in the Barwood Estate in the Ouchterlony valley in the Nilgiris in 1915, became known, is clear proof of the view that the presence of an effective insect on *Lantana* is not likely to be overlooked by the people affected.

It was, however, considered neither improbable nor impossible that there might exist unnoticed in some corner of the vast Indian continent an insect that might show definite tendencies towards combating the aggressiveness of *Lantana* and promise to give excellent results, when transported to

localities with more favourable climatic conditions. It was with this object in view that a thorough examination of all the *Lantana* areas in India was undertaken.

Though in certain tracts like Coorg, the presence of *Lantana* is almost offensively evident and the inhabitants cannot possibly afford to ignore its existence, there are, on the other hand, quite a number of places in India and Burma, where happily *Lantana* is either altogether non-existent or confined to fences around some of the bungalows, or only found growing stray as a garden escape. For purposes of the present investigation, it was not considered sufficient to restrict the examination of *Lantana* to areas where it is rampant and where, as evidenced by the luxuriance of its growth, the plant is not obviously being kept in check. The localities where the plant is not much in evidence are as interesting and probably of even greater import ; for though the paucity of *Lantana* in a particular place may, in many cases, be due to the unfavourable nature of the climate or the soil or possibly be accounted for by the recentness of its introduction, yet there is always the possibility that such particular locality may prove to be the Eldorado sought for, where the spread of the plant has been effectively checked by insect agency.

It is therefore imperative, if the inquiry were to be really thoroughly done, that as few of the places as possible where *Lantana* was known to be present should be omitted from visiting, but there were several limiting factors which stood in the way of a proper prosecution of the inquiry. Firstly, there was no definite information ready at hand in regard to many of the Provinces, as to the local distribution of *Lantana*, and some time had to be wasted by visiting the responsible local officers for acquiring the required knowledge. Secondly, in some of the places visited, the plant was not even recognized and I had laboriously to search it out myself. Thirdly, the time at which a particular locality is visited has a great deal to do with a proper examination of *Lantana*-feeding insects. For every tract there is a particular time when insects are found in greatest abundances and, if it be missed, few of them may be noticeable. The fact that I found very few insects on *Lantana* in a country so rich in insect life as Burma is perhaps to be attributable to my having visited that province in the dry weather, while an almost similar experience was the result of my visit during the cold weather to the Punjab, United Provinces, and the Central Provinces. Though the optimum period for each province varies owing to different climatic conditions, yet within certain limits this period is synchronous for most of the provinces, so that if the best results are desired, the inquiry will have to extend for a series of years. But, as the

period of deputation was more or less limited to about two years, the work had to be rushed through and in consequence has not been thorough in several respects.

Owing to want of time again, several tracts have had to be omitted entirely, such as Travancore and the extreme South of Bombay, Gujarat, Chota Nagpur, and Bengal.

However, what was really needed to be known was, whether there was at present existent in India any insect capable of acting as an effective check on *Lantana*, especially an indigenous insect of the nature of the seed-fly of Mexico introduced into Hawaii. If such an insect were really present in India the fact would, irrespective of the time of visit, easily have forced itself on my attention, for, even if it did not occur throughout the year, sufficient traces of its presence were bound to have been noticeable even in the most adverse part of the year. Hence, the knowledge that has been gained in regard to this question, though imperfect owing to the many gaps that have to be filled in, is sufficient to indicate the absence of any really effective pest to keep *Lantana* in check.

(b) Insects noted feeding on *Lantana* in India.

As may be evident from the list of insects given below, a fairly large number of insects have been noted on the *Lantana* plant in India and there is little doubt that the list might have been longer yet, if other parts of India had been examined and if some of the parts actually visited could have been examined at the right time of the year. Of the insects listed below, a great many were noted only once or twice, and in some cases only solitary specimens were observed, so that it was obvious that these were only casual visitors on *Lantana*, but as, in a great many cases, they were actually found feeding on the plant or might be presumed to be injurious to it from the very nature of their mouthparts and their feeding habits in general, they could not be discarded as unimportant insects, especially as it was considered not unlikely that, under different and more favourable conditions, they might occur in such numbers as to function as a check on *Lantana*.

The order followed in the arrangement of the families, in the list given below, is somewhat arbitrary, especially among the Lepidoptera. In this case, however, the Pterophoridæ and the Microlepidopterous families have been taken up first, as they were considered to be more important than the rest of the Lepidoptera as checks on *Lantana*.

LEPIDOPTERA.

Family Pterophoridæ.

1. *Platyptilia pusillidactyla*, Wlk. (Plate XXIV). It is one of the most efficient of the insects on *Lantana* in India. It chiefly feeds on the flower-buds and the flowers, thus checking the formation of fruits. The fruits are also attacked, especially the unripe ones, which the caterpillar hollows out and causes to turn prematurely black. The mature fruits are also bored into, but the real embryos, which are protected in special pockets of the hard shell, are not affected.

The tiny egg (Figs. 2, 3), which measures $\frac{1}{3}$ mm. × $\frac{1}{6}$ mm., is laid singly on the unopen flower-buds and sometimes also on the corollas of open flowers and on tender leaves. It is ellipsoid in shape and shiny opalescent-yellow in colour. The surface is rough, being covered with an irregular network of ridges. The egg hatches in four days. The young caterpillar bores into the base of one of the unopen flowers and attacks the ovary first and then the pollen-sacs. The adjacent flower-bud is next attacked in a similar way, the entrance being effected by tunnelling at the base (Plate XXXIV, fig. 1). Each caterpillar is able to destroy at least 15 to 20 of the flowers in a flower-head, and as it moves on from flower to flower, the line of its progress is marked by the shallow tunnel which it gnaws out of the surface of the flower axis. The full-grown larva (fig. 6) is about 5 mm. long, stout, bright yellow, and smooth. When mature it prepares a silken cocoon which is lodged in an enlarged part of its tunnel on the flower axis and covered over with the dried fruits or flowers (fig. 8). The pupa (fig. 9) is slender, elongate, cylindrical and yellowish-brown in colour; the hinder abdominal segments are armed dorsally by two pairs each of rather stout backwardly-directed spines, with the aid of which the pupa pierces the thin cocoon and, wriggling half-way out, allows the moth to emerge. The moth (fig. 11) has been recorded from all parts of India, Burma, and Ceylon, and is apparently a cosmopolitan insect having an almost world-wide distribution. It was evident, however, that it was not present in Hawaii, since it was one of the insects imported from Mexico and it is also clear that it is not to be found in Queensland since Mr. Tryon proposed in 1912 to import this moth along with the Agromyzid from Hawaii. [Outside of the Indian Region, it is known from the West Indies, Mexico, South America, Seychelles, Reunion, Hongkong, and Hawaii.—T. B. F.]

In India and Burma this insect was noticed by me feeding on *Lantana* both on the Hills and in the Plains in all the areas except the Punjab, where

Fig. 1. *Lantana* flowers attacked by caterpillars of *Platyptilia pusillidactyla*; Gorakhpur, December 1918.

Fig. 2. *Lantana* fruits webbed by *Lobesia* sp.; Kathgodam, U. P., December 1918.

it was conspicuous by its absence, but it is possible that its absence at the time of my visit in October was due to the cold weather having already set in.

This plume-moth also breeds in flowers and fruits of *Lantana indica* and *Lippia geminata*. The latter is an introduced American plant that has become acclimatized in parts of North-Eastern India, while the former is an indigenous species with a wide distribution covering the whole of tropical Asia and Africa. The widespread occurrence of its native foodplant easily accounts for the wide distribution of this moth in the Indian Region. The usefulness of this insect in checking the spread of *Lantana* is greatly minimized by the fact that it is subject to the attack of several parasites, one of which attacks the eggs and the others the caterpillars.

In Coorg I have noticed a small black Vespid with a narrow yellow band on its abdomen, *Icaria* sp. (near *aristocratica*) (T. V. Ramakrishna Ayyar det.) ripping open the cocoon of this plume-moth and carrying off the pupa.

FAMILY EUCOSMIDÆ.

(2) *Lobesia œolopa*, Meyr.

(3) *Lobesia genialis*, Meyr.

Both these species are found attacking the flowers and fruits of *Lantana*. The moths are extremely alike, so that it is difficult to distinguish* the one from the other, but the caterpillars are quite distinct.

The eggs are small, flattened and irregular in outline and hatch in about four days. They are laid singly on the tender leaves, on the flowers and on the fruits. The caterpillars of *Lobesia genialis* are green or yellowish-green, with the head marked by a lateral streak and the prothoracic shield bordered with black except anteriorly; while those of *Lobesia œolopa* are dark brown with prominent yellowish-white shields carrying hairs. The head is shiny black while the prothoracic shield is dark brown with a tinge of yellow.

The caterpillars web up the flowers and the fruits and feed on them. In the case of mature dry fruits they feed on the dry pulp and also partially bore into the seeds but do not damage the embryos. (Plate XXXIV, fig. 2.)

When mature they pupate generally in a fold of the leaf and the moth emerges in about eight days.

Lobesia œolopa, Meyr., is known to occur in Ceylon, Cape Colony, and Reunion. In Ceylon it has been recorded to breed on *Cajanus indicus* and has been bred from flowers of *Leucas* sp. at Pusa.

* The female moths are practically indistinguishable, but the males cannot be confused. [T. B. F.]

I have noticed both the species generally occurring together in most of the places where they have been noted, but *Lobesia genialis* was invariably the commoner of the two.

In South India *Lobesia* was noticed in plenty around Coimbatore, at the base of the Nilgiri Hills, and in Bangalore. It is less plentiful on the hills and in Coorg, Wynaad, and the Malnad of Mysore. It has not been noted on the Shevaroy Hills.

In Bombay it was noted in good numbers around Dharwar. In the United Provinces I noticed it only around Kathgodam where it occurred in fairly good numbers.

It is undoubtedly one of the more important insects on *Lantana*, but very rarely occurs in sufficient numbers.

4. *Argyroploce erotias*, Meyr. The caterpillars were on three different occasions collected feeding on *Lantana* flowers. The pupa is characterized by the presence of a pair of pits on the dorsal surface of the second abdominal segment.

Loc. Kallar and Bangalore.

5. *Argyroploce aprobola*, Meyr. Caterpillar collected feeding on *Lantana* flowers only on one occasion at Kallar, Nilgiris.

Family Tortricidæ.

6. *Cacœcia epicyrta*, Meyr. The caterpillars, which are cylindrical and vary from a light green to a dark brown in colour, web up adjacent flower heads and feed on the corollas, but are sometimes found also on shoots or on ripe fruits boring into the seeds but not injuring the embryos. The pupa of this species may be distinguished from that of allied forms by the first dorsal ridge of the abdominal segments being medially indented posteriorly to form a re-entrant angle.

This species was bred by me on *Lantana* at the following places :—*South India*: Coimbatore, Kallar, Bangalore, Sidapur, Manantoddy, and Yercaud; *United Provinces*: Dehra Dun; *Central Provinces*: Nagpur; *Burma*: Pyinmana.

It is a useful insect but hardly occurs in sufficient numbers to be effective.

7. *Homona menciana*, Wlk. The cylindrical, stout, greenish or yellowish caterpillar may fold the leaves at the tip of *Lantana* branches or web up the flowers and flower buds. The pupal period lasts about a week.

Collected from Kallar, Sidapur, and Vayitiri.

8. *Homona coffearia*, Nietn. Bred on one occasion from *Lantana* at Sidapur.

9. *Adoxophyes privatana*, Meyr. The larva webs up leaves and flowers of *Lantana*, pupates in a fold of the leaf and emerges in about eight days.

Loc. Coimbatore, Kallar, Manantoddy, and Coorg.

10. *Planostocha cumulata*, Meyr. Noted once at Kallar.

FAMILY PYRALIDÆ.

11. *Ephestia* sp. ? (unidentified). The flattened eggs are laid on the fruits, and the slender cylindrical caterpillars, which are marked by faint pink stripes, web up the fruit-clusters and feed on the dry pulp of the mature fruits. The kernel of the seeds is sometimes also eaten into, but their germinating power is not destroyed, the embryos not being reached.

Rarely flowers and tender leaves also are attacked.

Loc. Coimbatore, Mettupalaiyam, Bangalore, and Sidapur.

12. *Ephestia*? sp. A caterpillar, similar to the above but larger, was collected feeding on dry *Lantana* fruits. The moth which emerged was much larger and appears to be a distinct species.

Loc. Kathgodam, U. P.

FAMILY ARCTIADÆ.

12. *Diacrisia obliqua*, Wlk., var. *confusa*. Moths with the abdomen and the hindwings and sometimes also the forewings tinged with crimson.

In January 1917 several batches of young caterpillars were noticed at Bangalore. I am indebted to Mr. Kunhi Kannan of the Mysore Agricultural Department for the following information. Early in October 1917 when a bad outbreak of *Diacrisia obliqua* had been reported at Ilawal near Mysore on horsegram, cowpea, beans and *ragi*, it was observed that the caterpillars, after devastating the crops, had invaded the *Lantana* hedges and practically defoliated the bushes. When I visited the same village on the 28th October, 1917, and examined the hedges, I noticed that the bushes, though they showed clear evidences of having suffered from the caterpillars, had put forth fresh shoots and had thoroughly recovered.

This caterpillar was noted feeding on *Lantana* leaves and flowers in the following localities :—Bangalore, Jan. 1917 ; Ilawal (Mysore), Oct. 1917 ; Sidapur, Mercara (Coorg), Nov. 1917 ; Wynaad, Nov. 1917.

13. *Diacrisia obliqua*, Wlk., var. *todara*. Moths :—Males with abdomen and hindwings tinged with crimson and females with abdomen orange and wings buff.

Caterpillars found feeding on *Lantana* in small numbers in Coonoor, and Gudalur (Nilgiris), and in Yercaud (Shevaroys).

14. *Diacrisia flavens*, Moore (1879) ♀
Diacrisia eximia, Swinh. (1891) ♂

The male moths are reddish-yellow while the females are ochraceous and possess an anal tuft of buff colour.

The eggs are laid in close clusters on leaves and covered over with buff-coloured hairs. The number of eggs laid is quite large, ranging between 300 and 400. The egg is pale yellow in colour, smooth, shiny, and spherical.

In one instance, a female moth was noticed on 1st Nov., 1917, resting on the upper surface of a *Lantana* leaf at Sidapur, Coorg. Under its abdomen two eggmasses were noticeable, one larger than the other, and evidently they must have been deposited the previous night, 31st October–1st November. The eggs hatched on the 9th November, 1917, so that the egg stage appears to have covered in this case about nine days.

Out of a batch of caterpillars which hatched on 19-20th March, 1917, one was reared apart from the others. It cast its first moult on 24-25th March, second on 30-31st March, third moult on 5-6th April, fourth moult on 12-13th April, fifth moult on 18-19th April, and sixth moult on 25-26th April. It prepared a cocoon about the 2nd and pupated on 3-4th May. The moth emerged on 29-30th May, 1917.

The young caterpillars are gregarious up to the third instar and feed on the green matter of the leaves, reducing them to thin parchment. From the fourth instar they appear to drop off from the bushes and disperse, only stray individuals being noted, feeding either on the flowers or the leaves and sometimes on the fruits. The full-grown larva is 18–20 mm. long, dark brown in colour, the head and the prothoracic shield bright yellow. The segments carry dorsally pairs of large bright indigo-blue tubercles bearing bunches of dark brown setæ. Long grey hairs are also borne dorsally on the meso- and the meta-thorax and on the first, seventh, eighth and ninth abdominal segments.

In breeding cages the caterpillars prepared cocoons of silk, hairs and earth on the surface of the soil provided at the bottom. The pupa is thick-set, dark purplish-brown in colour and is 6½ to 8 mm. in length. The moths emerged in about two to three weeks after pupation, the emergence being observed to occur usually late in the afternoon.

It also breeds on *Diospyros montana* in Coorg. It has been noted in Coorg, the Wynaad, and the Anamalais.

Though noted in fairly large numbers at times, it is not much of a check on *Lantana*.

15. *Diacrisia indica*, Guer. Larva very similar to *Diacrisia flavens* (=*eximia*), but the head is reddish, the prothoracic shield is bright metallic

blue-black, and the dorsal shields carry a central bunch of three or four black spines and a peripheral circlet of short yellowish spines.

This species was noted feeding on *Lantana* at Mercara in Coorg and at Yercaud in the Shevaroys.

16. *Diacrisia* sp. (*lubricipeda* ?). A stray caterpillar collected at Coonoor.

17. *Pericallia ricini*, Fb. A few caterpillars were noted on *Lantana* at Gudalur (Nilgiris), September 1917.

18. *Amsacta albistriga*, Wlk. Hairy caterpillars, presumably of this species, were noted in some numbers on *Lantana* along the road between Hunsur and Mysore in July 1917. Moths could not be reared out.

19. *Creatonotus gangis*, Linn. A specimen of this moth was reared out from a caterpillar collected on *Lantana* at Coonoor in December 1916.

20. *Celama internella*, Wlk. The egg is circular, slightly flattened and finely sculptured and greenish-yellow in colour. The caterpillar is greyish-brown with a median dorsal whitish-yellow stripe. The lateral tubercles on the three thoracic and the seventh abdominal segment are bright orange-red. Only four pairs of suckerfeet are present. The larva feeds on the flower-heads and when full-fed builds a torpedo-shaped cocoon of strips of bark and the *Lantana* prickles spun up with silk. The moth emerges in about eight to nine days.

Loc. Coimbatore.

Hampson remarks that this species feeds on the fleshy shoots of *Rubus*, but spins in the open (*Fauna of Br. India*, Moths, Vol. II).

21. *Celama fasciata*, Wlk. Caterpillars were collected at Kallar (Nilgiris; 1200 ft.) (Dec. 1916) feeding on *Lantana* flowers; in appearance and habits similar to *Celama internella*.

The larva bears a very striking resemblance to that of *Euproctis scintillans*, but can be distinguished by the presence of only four pairs of suckerfeet. Pupal period in December ten or eleven days.

22. *Chionœma peregrina*, Wlk. Bred from a caterpillar found on *Lantana* flowers at Nadavanda (Mysore State), October 1917. The caterpillar builds a beautiful open cocoon out of its hairs.

23. *Asura rubricosa*, Moore. Bred from pupa found on *Lantana* leaf at Coimbatore.

Family Eupterotidæ.

24. *Eupterote* sp. Found in large numbers on *Lantana* bushes at Coonoor, Nilgiris, in December 1916.

25. ? *Eupterote* sp. Found in small numbers on *Lantana* leaves in Coorg and the Wynaad.

26. ? *Eupterote* sp. Found in small numbers on *Lantana*, Anamalai Hills.

All the above three *Eupterote* caterpillars were noted on *Lantana* but none of them could be reared into moths. None of them is very important.

Family Lasiocampidæ.

27. *Trabala vishnu*, Lef. Noted in very small numbers on *Lantana* in Coorg, the Wynaad, and the Anamalais.

It feeds on *Rubus* spp. in the Nilgiri Hills.

Family Lymantriadæ.

28. *Olene mendosa*, Hb. A brown and grey hairy caterpillar, carrying a pair of anteriorly directed tufts of grey-brown hairs and a median dorsal backwardly-directed pencil of brown hairs on the seventh abdominal segment; it feeds on the flower-heads of *Lantana*. It has been found in moderate numbers in most places in South India both in the Hills and in the Plains. It is a very useful species, as each caterpillar is able to account for the destruction of at least ten flower-heads, but it is never found in large numbers and is subject to the attacks of parasites. It is a minor pest of cultivated crops.

29. *Euproctis scintillans*, Wlk. Hairy caterpillars found feeding on the flowers both in the Hills and in the Plains in South India.

In North India I have noted it at Dehra Dun.

The larvæ feed exclusively on the flower-heads and would form a fairly efficient check on the seeding of *Lantana* if they were present in large numbers. It is, however, a pest of several cultivated crops and is freely attacked by parasites.

A single specimen of *Euproctis fraterna* was reared, feeding on flowers at Gorakhpur.

30. *Euproctis flavinata*, Wlk. Caterpillar :—trunk brown : head brown : anterior tufts grey : first and second abdominal hair-cushions brown surrounded by a yellow circlet : third abdominal cushion grey : posterior tufts, the mid-dorsal line and the anal tuft grey. Found in some numbers feeding on *Lantana* flowers at Sidapur, Coonoor, Gudalur, Pudupadi, Yercaud, etc.

31. *Euproctis* sp. Kallar : bred from caterpillar feeding on flowers. Moth with a dot on forewing.

32. *Euproctis flava* and *E. digramma*. Both were captured as adults resting on *Lantana* leaves, Sidapur. Possibly their larvæ feed on *Lantana*.

33. *Orgyia postica*, Wlk. Caterpillars on *Lantana* in small numbers at Bangalore.

It is also a pest on crops.

34. *Porthesia xanthorrhœa*, Koll. Caterpillars attacking *Lantana* flowers at Bangalore, January 1917.

35. *Leucoma subvitrea*, Wlk. Bred from a single caterpillar found on *Lantana* leaf at Mount Stuart, Anamalai Forests, December 1917.

FAMILY NOCTUIDÆ.

36. *Hypena* sp. (near *abyssinialis*). Eggs greenish, flattened and sculptured, laid singly by side of the veins on under-surface of *Lantana* leaf. The caterpillar, when full-grown, is about 18 mm. long, and is light green with numerous small dot-like shields carrying moderately long black setæ. There are only four pairs of prolegs. A caterpillar that hatched on the 3rd December, 1916, prepared its cocoon on the 22nd December, pupated on the 23rd December, and emerged on the 2nd January, 1917. The larvæ feed on the green parenchyma of the leaves, the portions eaten into turning into conspicuous whitish blotches. They also feed largely on flowers and sometimes on fruits. A single caterpillar may destroy several flower-heads. Pupation occurs generally in a fold of the leaf. This species also breeds on *Lantana indica* and *Lippia geminata*.

Loc. Found in most places in South India, abundantly at Bangalore and Coimbatore. It was noted in small numbers at Gurdaspur in the Punjab. Traces of its presence were noted in many places in the United Provinces and the Central Provinces. In Coorg it was found to be kept in check by Tachinid parasites.

It is especially abundant just after the Rains.

37. *Eublemma abrupta*, Wlk. Eggs yellow, shiny, hemispherical: surface pitted and armed with numerous tiny capitate processes: $\frac{1}{2}$ mm. in diameter: laid among the flower buds.

The caterpillar is a true semilooper with only three pairs of prolegs. The general colour is a dark velvet-brown variegated with patches of black and bright yellow. The larva presents a bizarre appearance owing to the presence of 5 or 6 pairs of prominent black clubbed hairs borne on wart-like shields on the anterior segments of the body. These clubbed hairs are not present in the newly hatched caterpillar but appear in the third instar. Pupation occurs in a cocoon built of silk and excreta. The larval period varied from 9 to 15 days while the pupal stage may last 12 to 21 days. In one case eggs collected on 12th May, 1917, hatched on 17th May, 1917, at Sidapur.

Loc. Noted at Coimbatore, Kallar, and Sidapur (Coorg). Found usually in small numbers, but the caterpillars feed largely on the flower-heads and sometimes eat into immature fruits. According to Moore's *Lepidoptera of Ceylon* this species feeds on *Ficus parasitica* in Ceylon.

38. *Eublemma silicula*, Swinh. The eggs are more or less spherical, minutely sculptured and armed with numerous tiny clubbed hairs and are $\frac{1}{2}$ mm. in diameter. The larva is a true semilooper, somewhat hairy, yellowish-brown with darker patches. It lives among the flower clusters or the fruit-bunches, surrounding itself with a light silken webbing, and feeds from within. I have reared it on *Lantana* only at Coimbatore in South India and at Haldwani and Kathgodam in the North. It usually breeds in earheads of *Sorghum* in South India.

39. *Agrotis c-nigrum*, Linn. A large cluster of yellowish small spherical eggs about 90 in number, found deposited on a *Lantana* leaf, was collected at Runnymede, Nilgiris, on the 30th December, 1916. The eggs hatched on the night of the 1st January, 1917, and the larvæ, after undergoing four moults, pupated in mud cells between the 6th and the 10th January and emerged between the 24th February and the 4th March, 1917.

The caterpillars fed freely on *Lantana* leaves in the cages.

40. *Heliothis obsoleta*, Fb. Caterpillars of this cosmopolitan insect were noted feeding on *Lantana* flowers on different occasions at Mercara and Bangalore.

FAMILY GEOMETRIDÆ.

41. *Hemithea* sp. (near *tritonaria*). Egg yellowish, elliptical in outline, rather flattened, somewhat resembling a miniature cake of Pears' soap in shape; laid singly on the corollas of flowers.

The caterpillar is a dark brown looper, which masks itself dorsally with bits of flowers and other dead plant tissues attached by silken threads to peculiar anchor-shaped spines found on its body. It feeds on the flowers and pupates in a loose cocoon formed of rubbish spun together with silk. A caterpillar which hatched on the 2nd December, 1916, pupated on the 3rd January, 1917, and emerged on the 15th January, 1917. Another which hatched on the 8th December, 1916, pupated on the 3rd January, 1917, and emerged on the 14th January, 1917. The pupal period varies from 9 to 13 days.

The adult is a prettily coloured moth of a light green colour.

Loc. Coimbatore, Bangalore, and Yercaud.

42. *The small Geometrid* (not identified). Eggs are small, oval, slightly depressed, and yellowish in colour. The caterpillar varies from a pale yellow

to a dark brown in colour, the sides striped with pale brown. The caterpillar is very slender and is about 12 mm. when full-grown.

The larval period varies from 10 to 12 days while the pupa takes 9 to 11 days to emerge. The moth is yellow-brown marked with brown undulations.

The caterpillars feed on the florets and have been found in fairly good numbers in places. Noted at Sidapur, Coimbatore, the Wynaad, the Nilgiris, etc. Noted also in Burma, at Shillong in Assam, at Kathgodam, Cawnpur, and Nagpur (?)

43. *Biston suppressaria*, Gn. A larger looper found feeding on *Lantana* leaves at Kallar, December 1916.

44. *Hyposidra talaca*, Wlk. A large yellow-brown looper found feeding on *Lantana* leaves at Coimbatore.

45. *Boarmia bhurmitra*, Wlk. A looper feeding on leaves; Yercaud, August 1917.

Family Hypsidæ.

46. *Argina syringa*, Cram. Caterpillars of this species were found feeding on *Lantana* leaves in January 1917. Pupation occurred in fold of leaves.

Loc. Bangalore.

Family Sphingidæ.

47. A *Sphingid*. Eggs were noted on *Lantana* leaves at Sidapur in April but, being parasitized, did not hatch. Mr. F. Hannyngton, I.C.S., then Commissioner of Coorg, informed me that he had noted a Sphingid breeding on *Lantana* in Coorg during the rains.

Family Psychidæ.

48. *Clania crameri*, Westwood. The larvæ live in tough cases of silk overlaid by an armour of bits of dry twigs. They have been found in small numbers feeding on leaves at Coimbatore, Sidapur, and the Wynaad. The male moths are winged while the females are wingless and live in the larval cases.

Family Arbelidæ.

49. ? *Arbela tetraonis* (probably). In the hilly upland tracts of Gudalur (Nilgiris), the Wynaad, and Coorg, the branches and sometimes the stems of *Lantana* were, in certain localities, attacked by an Arbelid caterpillar, which retreated into a central tunnel during the daytime and fed on the live bark at night under cover of a gallery of silk and bits of bark and excreta. The affected branches exhibited symptoms similar to those of the bark-fungus noted

in the same area. The leaves gradually turned red and the whole branch ultimately dried up. Moths could not be reared out.

At Shillong *Lantana* twigs were noticed to have been attacked in a similar way by a similar Arbelid caterpillar, but it is not possible to say if it is identical with the above, as moths were not bred out. The caterpillar was parasitized by a Tachinid. Branches of a species of *Rubus* were similarly attacked at Shillong.

Family Lycænidæ.

50. *Zizera gaika*, Trim. In March 1917, a solitary caterpillar of this species was found feeding on immature *Lantana* fruits at Sidapur, Coorg. No other example of this caterpillar was found later. It is interesting in view of the fact that there are two Lycænids in Mexico that feed on *Lantana* flowers and fruits. The butterfly was kindly identified for me by Mr. F. Hannyngton, I.C.S., until recently Commissioner of Coorg.

According to Bell (*Jour. Bombay Nat. Hist. Soc.*, Vol. XXV, p. 443), this butterfly breeds in the flowers of *Nelsonia campestris* (Acanthaceæ) in Kanara.

The larva was about 7 mm. long, flattened, more elongate than broad, light green with several grey-margined stripes of violet colour. The body was thickly covered with close-set short feathery hairs. Hindmost segment flattened, possessing a pair of white papillæ.

It pupated on the 17th March and emerged on the 24th of the same month.

COLEOPTERA.

Family Melolonthidæ: Sub-family Cetonianæ.

51. *Protœtia aurichalcea*, F.;
52. *Oxycetonia versicolor*, F.;
53. *Anthracophora crucifera*, F.

These three species of Cetoniad beetles were found attacking *Lantana* between November and January. They bite into the base of the axis of the flower-heads and appear to feed on the juices that exude from the injured parts. They have been observed to remain clinging to the bases of the flower axis for hours together, without making the slightest movement during the whole time. The axis of maturing fruits may similarly be attacked. Affected flower-heads are completely destroyed.

These beetles also attack earheads of *Sorghum* and feed on the milk of the developing grains.

Loc. Noted on *Lantana* at Coimbatore in South India and at Dharwar in Bombay (September 1918).

SUB-FAMILY MELOLONTHINÆ.

54. . . . . (not identified). This small beetle was found feeding on the flowers of *Lantana* in small numbers in June 1918 at Shillong. It was noted in much larger numbers on rose flowers.

SUB-FAMILY RUTELINÆ.

55. *Popillia birmanica*
56. *Popillia cupricollis*
57. *Anomala variivestis*

} Found feeding on *Lantana* flowers, Shillong, Khasi Hills.

FAMILY MELOIDÆ.

58. *Zonabris phalerata.* Anamalai Hills, Dharwar, Gauhati, Barapani (Khasi Hills).

59. *Zonabris* sp. Bangalore.

60. *Zonabris cichorii.* Found at Gauhati and at Barapani (Khasi Hills; 3,000 ft.).

These blister-beetles were found feeding on *Lantana* flowers in small numbers. Though these beetles are plentiful at Coimbatore, it was remarkable that none were noticed going to *Lantana.*

FAMILY CURCULIONIDÆ.

61. *A small weevil,* resembling *Baris neelgheriensis* but smaller, black with a few yellowish dots, was found in numbers at Bangalore in July 1917 frequenting the flower-heads of pink *Lantana.* They ate small holes into the bases of the corollas, but it was evident that they were not engaged in ovipositing. Most of them were found in pairs.

62. *Baris neelgheriensis.* One solitary specimen found on a flower-head at Coonoor, August 1917.

63. *Myllocerus delicatulus.* On leaves in small numbers at Yercaud; it was also noted on *Lantana indica* in the Shevaroys.

64. *Myllocerus viridanus.* Coimbatore; in small numbers on leaves.

65. *Phytoscaphus triangularis.* Noted on *Lantana* leaves at Lucknow, December 1918.

66. *Sympiezomias sulphuratus.* On *Lantana* leaves; Katteri Road (Nilgiris).

FAMILY SCOLYTIDÆ.

67. *A small Scolytid* was found attacking the dry portions of twigs killed by the bark fungus in Coorg and the Wynaad. The beetle bores tunnels into

the wood and lays eggs, the grubs hatching from which would apparently seem to continue their work. (Plate XXXV, fig. 3.)

Possibly there are two species concerned—one larger than the other. The specimens have been sent to Mr. C. F. C. Beeson, Forest Zoologist, Dehra Dun, for favour of identification.

Family Bruchidæ.

Several Bruchids (including *Bruchus* spp. and *Spermophagus* sp.) were on different occasions noticed among *Lantana* flowers, on which they presumably feed; but they were generally found in very small numbers and are of very little importance.

DIPTERA.

Family Cecidomyiadæ.

68. *Asphondylia* sp. (probably* *sesami*, Felt). The *Lantana* gall-fly is a small dusky-coloured fly which appears to be nocturnal in habits. The female possesses a long stylet-like ovipositor which is completely retracted into the body when not in use; the young flower-buds would appear to be pierced by the stylet and the eggs then laid among the pollen-sacs inside. The maggot feeds on the pollen-masses and causes the formation of the gall which resembles a large unopen flower-bud in most respects except for a peculiar bulge in the middle. When full-grown it turns into a pupa, the cephalic end of which is armed with a set of short stout spines, which are used by the pupa for boring its way partly out of the gall so as to enable the fly to emerge. In a small number of cases the fly also attacks tender fruits, the maggots having been observed to feed inside the berry. The affected fruits are easily distinguished by their elongate-oval shape. (Plate XXXV, figs. 1, 2.)

These galls have been found mostly in the hilly tracts belonging to the Western Ghats ranges in the Indian Peninsula. They have been collected in Coorg, the Wynaad, Gudalur and Kallar (Nilgiris), the Anamalais, Malabar (Tamarasseri, Pudupadi and Calicut), Dharwar and Londa in Bombay, Sagar in Mysore, and the Ramandrug Hills in the Bellary District. They have not been noted in the Plains nor at Bangalore and Tumkur nor in the Shevaroy Hills.

At Nagpur some of the *Lantana* bushes exhibited a curious malformation of the flowers. The corollary tubes of the diseased flowers were stunted and

* Dr. E. P. Felt has since informed us that the *Lantana* Cecidomyiad is quite distinct from *Asphondylia sesami*. A description of the *Lantana* gall-fly will be found in Vol. VII, part 1, of these Memoirs. [T. B. F.]

Fig. 1.

Fig. 2.

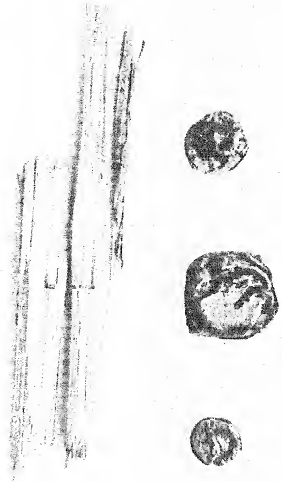


Fig. 3. Sections of *Lantana* stems attacked by a Scolytid beetle in Mysore.

bulged and irregularly developed, showing a somewhat striking resemblance to *Lantana* galls, although in these cases the flowers had opened. In most cases the pollen-sacs were found damaged, though traces of any insect were not noticeable. Young unopen buds were also examined under the microscope and in three cases a small maggot of the Cecidomyiad type was noted among the pollen-sacs. Getting information from Mr. J. L. Khare, Entomological Lecturer, Nagpur, of the occurrence of galls in *Sesamum* I collected the galls from the Farm fields and was able to rear the adults of *Asphondylia sesami* from them. The undoubted occurrence of this fly at Nagpur when coupled with the cases of malformed *Lantana* flowers noted above is of peculiar significance in relation to the question of the identity of the *Lantana* gall-fly.*

This gall-fly is undoubtedly beneficial to a certain extent, as in favourable seasons a large percentage (nearly 30%) of the flowers may thus be attacked. Generally only 2 to 7 flowers out of 25 or 30 in a cluster are transformed into galls, though in one case as many as 16 were noted in a cluster of 25.

The usefulness of the fly is very greatly diminished by the fact that it is heavily parasitized, at least three Chalcidids and a Braconid having been reared out from these galls.

These flower-galls have been noted also on *Lantana indica* in Coorg and in the Nilgiris.

Flies have been reared out and are presumably identical with the *Lantana* gall-midge. It was somewhat surprising to find that, at high elevations (5,000–6,000 ft.) in the Nilgiris, galls occurred only on *Lantana indica* to the exclusion of *L. camara* though the red variety of the latter was plentiful. At 3,000 feet galls were found in both.

It was also interesting to note that these galls are observable only on the red variety of *Lantana camara*. None have been noted on the pure pink variety, though in two or three solitary cases galls were noted at Gudalur and in Coorg on pink hybrids.

If this fly proves to be identical with *Asphondylia sesami*, Felt, which is a fairly bad pest on *Sesamum* and clusterbeans at Coimbatore, it will be an insect which one should be careful about introducing into other places.*

FAMILY DROSOPHILIDÆ.

69. ....(not named). This fly was found breeding in good numbers in the pulp of the large-sized fruits of a pink variety of *Lantana* which I noticed around Coonoor in the Nilgiris. The seeds were unaffected.

* See, however, footnote on page 292.

An Ortalid fly (*Ceroxys* sp.) was bred out from fruits of *Lantana indica* collected near Kotagiri, and a *Mycetophilid* from the fruits of the same plant near Sidapur.

ORTHOPTERA.

Family Acridiidæ: Sub-family Pyrgomorphinæ.

70. *Orthacris acuticeps*, Bol. This is a wingless grasshopper which has been found attacking the flower-buds and the flowers around Coimbatore, Bangalore, Madras, Hebgod (Mysore State) and Ramandrug (3,500 ft.).

71. *Orthacris ruficornis*, Bol. This is another wingless grasshopper which is restricted to the Hills of Southern India and has been noted on *Lantana* in the Nilgiris, the Shevaroys and the Anamalais. The Nilgiri variety is a metallic bluish-green while the one found in the Shevaroys and the Anamalais is a metallic light green. Large numbers were noted on *Lantana*, both the adults and the young ones feeding freely on the leaves and the flowers. Some of the hedges in the neighbourhood of Coonoor were found badly attacked in August 1917. The grasshopper, however, disappears after September. It also feeds on *Dodonæa viscosa* on the hill sides near Coonoor.

72. *Aularches miliaris*, L. In Coorg, the young ones hatch in April from eggs laid in the soil the previous year and feed gregariously on almost any plant they find growing near by. Large numbers of the young ones were noted on some of the *Lantana* thickets near Rockhill, Sidapur, and some of the bushes were almost entirely defoliated by them. As they grew bigger they dispersed and were therefore only occasionally noticed on *Lantana*. The adult grasshoppers have on a few occasions been noticed feeding on the flower-buds.

73. *Pyrgomorpha brachycera*, Kirby. This has been found occasionally on *Lantana* around Gudalur and in the Wynaad.

74. *Pyrgomorpha conica*, Oliv. This species was found feeding on *Lantana* leaves and flowers in very small numbers at Hoshiarpur and Dhariwal in the Punjab.

75. *Atractomorpha scabra*, Thurb. A few were observed feeding on *Lantana* at Kathgodam, U. P. Young ones were also noticed.

76. *Atractomorpha blanchardi*, Kirby. A few were noticed on *Lantana* at Dhariwal in the Punjab. Young ones were also observable.

Sub-family Eumastacinæ.

77. *Mastacides vaginalis*, Sauss (?). A green, short-horned, wingless grasshopper which has the peculiar habit of resting on leaves with its hind legs

stuck out sidewise at right angles to the body. It has been found in small numbers in the Wynaad, Coorg and the Anamalais attacking the flowers and leaves of *Lantana*. It also feeds on some other plants in Coorg.

SUB-FAMILY CATANTOPINÆ.

78. *An undescribed grasshopper* (probably near *Wacata*). This species was noticed in fairly good numbers at Sidapur (Coorg) in March-April 1917. Young ones were found in plenty in March and by May they had become full-grown. The young hoppers are yellow-brown in colour while the adults assume a beautiful bright metallic blue. The mature grasshoppers have long filiform antennæ, and relatively large eyes ; the tegmina and the wings are both absent and the prosternal tubercle is very feebly developed. They are very alert and active and feed chiefly on the leaves, eating numerous holes into them, and sometimes also on the flowers. This species was found feeding on other shrubs also in Coorg ; it has also been noticed to be present in the Wynaad, in the Anamalais, at Sagar in Mysore and at Castlerock.

79. *Coptacra* sp. ? Found on *Lantana* at Gauhati, Assam, in July 1918.

80. *Catantops splendens*, Thunb. Found on *Lantana* at Gauhati, Assam, July 1918.

SUB-FAMILY TRYXALINÆ.

81. *Aiolopus tamulus*, F. Found on *Lantana* at Dehra Dun.

FAMILY PHASGONURIDÆ.

82. *Letana atomifera*, Brunn. A long-horned grasshopper of green or greenish yellow colour. The tegmina are elongate and leaf-like, the ovipositor short and curved. It has several times been noticed feeding on the leaves and the flowers of *Lantana*. A grasshopper, which was kept alive in a pillbox and fed on *Lantana* leaves, laid eggs in the tissues of one of them. It has been collected on *Lantana* at Coimbatore, Bangalore, Ramandrug (Bellary District) Dehra Dun and Kathgodam (U. P.), Nagpur (C. P.).

83. *Ducetia thymifolia*, Fb. (?). Found on *Lantana* at Gauhati.

84. *A small Phasgonurid* (*Anisoptera* ?). An immature specimen was found at Yercaud (Shevaroys), biting into the corollas of flowers at their base, presumably in order to feed on the pollen-sacs but possibly also to attack the young Thrips inside. One specimen was kept in a pillbox and lived therein for nearly two months invariably biting into the base of the corollas of the flower-heads provided as food.

Two other species of Phasgonurids were collected on *Lantana* but are unimportant.

Family Phasmidæ.

A few Phasmids were observed in different places resting on *Lantana* leaves, but it is doubtful if they feed on *Lantana*.

ISOPTERA.

Family Termitidæ.

85. *Termes* (*Macrotermes*) *annandalei*, Silv. This species was noticed attacking the stems of *Lantana* plants in a hedge found in the garden of the Superintendent of the Northern Shan States, at Lashio. The plants were fairly old and some of the attacked bushes were found drying up.

86. *Microcerotermes heimi*, Wasm. This termite was found attacking the stems of old *Lantana* bushes found on the plateau at Ramandrug (Bellary District). Only stray plants were attacked but the affected plants did not show any obvious signs of damage.

RHYNCHOTA.

Family Pentatomidæ.

87. *Plautia fimbriata*, Fabr. This bug has been noted on *Lantana* in a great many places in India and Burma ; Coorg, the Wynaad, Coimbatore, Nilgiris, the Anamalais, Bangalore, Burma (Rangoon, Pyinmana), Gurdaspur (Punjab). The eggs are laid in small clusters on the leaves and the young ones that hatch out migrate to the fruit-bunches. The adult bugs also attack the fruits. Though I could not ascertain how far the bugs, whether young or mature, actually affect the germinating power of the fruits, my observations of *Lantana* bushes infested by this bug lead me to conclude that it is not effective to any appeciable degree.

Mr. H. N. Ridley in his article on " Endemism and the Mutation Theory " (*Annals of Botany*, Vol. XXIX, No. CXX, October 1916, pp. 552-553) makes the following remarks :—" When I first arrived in Singapore in 1888, this shrub (*Lantana mixta*) was very abundant all over the waste-ground in Singapore ; on my last visit there it had become comparatively scarce — one had to look about the country for it. I found a plant in the edge of the wood by the roadside, and on examining it found that every one of the young fruits on the whole bush was perforated by a small green Bug (*Plautia fimbriata*) and that all those fruits which had been sucked by the bug withered up and never came to maturity." As these observations were not confirmed by our experience in India, the question was referred by the Imperial Entomologist to

Dr. Hanitsch, Curator of the Raffles Museum, Singapore, who did not support Mr. Ridley's views. He remarked in his letter :—"I cannot say that during the 22 years I have been here I have found the slightest decrease of *Lantana*, except of course, so far as there is nowadays so much more and in Singapore, the Straits and F. M. S. under cultivation than formerly. The hedges in the Museum compound, in my private garden, all along the roads in the suburbs of Singapore are, as far as I can see, as full as ever of this plant."

This bug appears to have a very wide distribution in the Tropics, having been recorded from Ceylon, Burma, Tenasserim, Malay Peninsula and Archipelago, China, Japan and Madagascar.

88. *Plautia viridicollis*, Westwood. This bug very closely resembles *P. fimbriata* and is distinguished from it by its smaller size, the punctures on the pronotum and the scutellum being coarser, the apex of the scutellum being broadly greyish and the dorsal surface of the abdomen being violaceous instead of red.

It occurs in smaller numbers on *Lantana* in company with *P. fimbriata* and is much less common. It has been recorded by me from Mettupalayam, Coimbatore, Nilgiris, Wynaad (Manantoddy).

Recorded in the *Fauna of British India* from Java and Ceylon.

89. *Halyomorpha picus*, Fabr. A dark-brown bug of moderate size, found on *Lantana* bushes in a great many places in India. The eggs are usually laid on leaves. In one instance an egg-cluster, found laid on the undersurface of a *Lantana* leaf at Sidapur, contained 25 eggs, which were more or less spherical with both the poles considerably flattened; opaque-white in colour, about 1·25 mm. in diameter, and with the egg-cover surrounded by a circlet of tiny knobs. The eggs, which were collected on the 27th March, 1917, hatched on the 30th March, 1917, into small black and yellow nymphs. Two of the nymphs reared separately gradually passed through 5 moults and became adults on the 5th and the 8th May, 1917, respectively.

The half-grown nymphs are flattened and are very dark in colour and can be easily recognized. Both the nymphs and the adults are found feeding on fruits, but as they generally seem to feed chiefly on the pulp of the mature fruits, they are of very little use as a check on *Lantana*.

According to Distant, this species has a wide distribution outside India, being recorded from Ceylon, China, Japan and Malaya.

On *Lantana* I have noted it from the following places :—Coimbatore, Coorg, Nilgiris, Wynaad, Ramandrug (Bellary), Dharwar, Burma, Haldwani (U. P.).

90. *Halys dentatus*, Fabr. Found on a few occasions on *Lantana* fruits, Bangalore.

91. *Tolumnia latipes*, Dall. ? A striking darkish bug with bright yellow spots on the scutellum : found in small numbers on *Lantana* fruits at Sidapur (Coorg), Wynaad, Bangalore and Gauhati (Assam).

92. *Dolycoris indicus*, Stål. Found on *Lantana* fruits, Shillong, Assam.

93. *Antestia cruciata*, Fabr. Found on *Lantana* fruits in small numbers chiefly in the Hills, Nilgiris (Cooncor and Katteri), Shevaroys (Yercaud) and also at Coimbatore.

94. *Nezara viridula*, Linn. Sometimes found feeding on *Lantana* fruits : noted at Bangalore, Sidapur, Pollibetta in Coorg, in Burma, at Kathgodam and Dehra Dun in U. P.

95. *Catacanthus incarnatus*, Dru. Found once at Coimbatore on *Lantana* : Mr. P. V. Isaac coll.

96. *Cantao ocellatus*, Thurb. Found once at Sidapur on *Lantana*.

97. *Chrysocoris stollii*, Wolff. Found on *Lantana* at Pusa (A. G. R. coll.) and also at Gauhati in Assam.

98. *Placosternum taurus*, Fabr. Occasionally on *Lantana*, Bangalore.

99. *Brachycerocoris camelus*, Costa. A small bug of rather bizarre appearance. Found breeding in small numbers on *Lantana* berries at Malleswaram, Bangalore, July 1917.

100. ? *Hoplistodera* sp. Found in small numbers on *Lantana*, Shillong.

Family Coreidæ.

101. *Clavigralla gibbosa*, Spin.
102. *Clavigralla horrens*, Dohrn.
} Noted on *Lantana* flowers, Coorg and Coimbatore.

103. *Acanthocoris scabrator*, Fabr. Once noted on *Lantana* in Coorg (Sidapur).

104. *Homœocerus striicornis*, Scott. Noted on *Lantana* ; Bangalore, Gauhati, and Shillong.

105. *Homœocerus inornatus*, Stål. Collected on *Lantana* leaf, Cawnpur, December 1918.

106. *Riptortus linearis*, Fabr.
107. *Riptortus pedestris*, Fabr.
} Both found in small numbers on *Lantana* flowers, Coorg.

108. *Cletomorpha raja*, Dist. Found on numerous occasions on *Lantana* flowers in Coorg : it is found in fairly good numbers. Once noted also at Dharwar.

109. *Cletus rubidiventris*, Dist. In small numbers on flowers ; Coimbatore, Sidapur, and Ramandrug.

110. *Corizus rubicundus*, Sign. This small bug has been taken on several occasions on *Lantana* flowers, on which they usually cluster in groups of 3 to 10 : noted chiefly in Coorg, but also collected at Pyinmana in Burma and Dehra Dun and Bangalore.

Family Lygæidæ.

112. *Melanotelus* sp. In small numbers on flowers ; Sidapur (Coorg).

113. *Aphanus* sp. On flowers ; Pollibetta (Coorg).

114. *Lygæus hospes*, Fabr. On *Lantana*, Dinanagar, Punjab.

115. *Lygæus* sp. On *Lantana*, Sidapur.

116. *Geocoris tricolor*, Fabr. On *Lantana* flowers, Coimbatore, Gurdaspur and Pyinmana.

Family Pyrrhocoridæ.

117. *Physopelta gutta*, Burm. On *Lantana*, Coorg.

118. *Dysdercus cingulatus*, Fabr. Found in small numbers on flowers and fruits ; Sidapur, Shillong, Gauhati, Kyidaunggan, Pyinmana, Dehra Dun, Sarna.

Family Phymatidæ.

119. *Amblythyreus* sp. Found on *Lantana* leaves, Anisakan, Burma (3,000 ft.).

Family Capsidæ.

120. *Megacœlum stramineum*, Wlk. Noted on one occasion on *Lantana* flowers, Kallar (1,200 ft.), Nilgiris.

121. *Megacœlum* sp. Laying eggs in axis of *Lantana* flowers ; Runnymede (5,000 ft.) and Katteri (5,500 ft.), Nilgiris.

122. ? *Pœciloscytus longicornis*. Found occasionally on *Lantana* flowers : Sidapur, Coonoor.

123. *Derœocoris* sp. ? On *Lantana* flowers : Coimbatore, Dehra Dun.

124. ? *Lygus* sp. On *Lantana* flowers, Coimbatore.

125. ? *Campylomma* sp. A small green Capsid found in moderate numbers on *Lantana* flower-heads in a great many places in India : Dehra Dun, Sarna, Hoshiarpur, Kathgodam, Cawnpur, Dariaoganj, Nagpur, Kallar (Nilgiris).

The bug lays eggs in the tissues of the flower axis and the young ones that hatch out suck the juices of the flower-heads. When found in sufficiently good numbers, the flowers of attacked flower-heads drop off.

126. *Helopeltis antonii* ? Noted on one occasion on *Lantana* at Pyinmana in Burma, where it also attacks *Nîm* trees as in India.

Family Anthocoridæ.

127. *Triphleps* sp. This small bug has been noticed among *Lantana* flowers in a great many places in India, running in and out of the corollary tubes. It is presumably a predator probably feeding on the Thrips that infest the flowers.

Family Fulgoridæ.

128. *Ricania marginalis*, Wlk. Found in small numbers on the branches at Sidapur, Coorg.

129. *Ricania coorgensis*, Dist. Found on *Lantana* in small numbers in Coorg.

130. *Ricania bicolorata*, Dist. Between January and March *Lantana* bushes at elevations of 2,000 to 3,500 ft. near Hillgrove on the Nilgiris were found infested with large numbers of the young ones of this species. The nymphs possess long and conspicuous white mealy appendages and branches covered by these bugs looked from a distance as if they were attacked by mealy bugs. In spite of the large numbers present, *Lantana* branches did not evince any signs of serious injury. These bugs were also noted on various other low-growing shrubs.

131. *Eurybrachys* sp. Occasionally found on *Lantana* in S. India.

Family Membracidæ.

132. *Leptocentrus taurus* ? Occasionally on *Lantana*, Dhariwal, Punjab.

Family Cercopidæ.

133. *Ptyelus præfractus*, Dist. Found breeding on *Lantana* in the Wynaad and Coorg in November 1917. The young ones are enveloped in spittle and attack the twigs. Found, however, only in small numbers.

134. *Phymatostetha deschampsi*, Leth. Found on *Lantana* in the Wynaad.

Family Jassidæ.

135.........a Jassid (not identified). A slender green and brown species: found in small numbers on *Lantana* at Dehra Dun.

136. *Idiocerus atkinsoni*, Leth. Occasionally found on *Lantana*: Fatehgarh, Dehra Dun, etc.

137. *Idiocerus clypealis*, Leth. Found in small numbers on twigs: Hoshiarpur, Fatehgarh, etc.

138. *Tettigoniella ferruginea*, Fabr. Found in small numbers on *Lantana* bushes in the Western Ghats region, Coorg, Wynaad, etc.

Various other bugs including Jassids, Cercopids and Fulgorids have been collected on *Lantana*, but they have not been identified and are of very little importance individually.

FAMILY APHIDIDÆ.

139. . . . .(Identity not known). *Aphis* is sometimes found infesting whole bushes, causing a diminution of seeding, as round about Coimbatore. It, however, appears only after the Rains.

FAMILY ALEYRODIDÆ.

140. *Aleyrodes* sp. (probably *A. ricini* ?). An overgrown hedge of the pink variety of *Lantana* was noticed along the side of the railway embankment to the left of the road leading to Sitabaldi. The plants in this hedge were infested with large numbers of whiteflies. All the older leaves were more or less thickly covered with the scales on the under surface, while on the tender leaves and shoots large numbers of the milk-white adult flies were found clustering together. Innumerable eggs were noticed to have been laid on the tender leaves. In spite of the large numbers of the Aleyrodid, the plants were not observed to show any appreciable signs of damage. In a public garden at Cawnpur, similar whiteflies were noted on *Lantana*, but eggs and larvæ were not observed on it though certain low shrubs near by, probably *Adhatoda vasica*, were thickly covered both by the larvæ and the adults.

A small number of the whiteflies were always noticeable among the flowers in a great many places in North India, having been collected at Gurdaspur, Pathankote, Hoshiarpur, Dehra Dun, Kathgodam, Lucknow, Cawnpur, and Nagpur, but in none of these places except the last was the insect found actually attacking the *Lantana* plant.

A small yellow parasite was reared out from the larvæ.

FAMILY COCCIDÆ.

141. *Pseudococcus* sp. This species was commonly found on *Lantana*, affecting the leaves, fruits and the flowers, throughout South India, but was present in small numbers.

142. *Pseudococcus* sp. (*virgatus* ?). This species differed from the preceding both in form and habits. It was noted on *Lantana* in Bangalore in May 1917. It was very gregarious and occurred in masses both under the leaves and on the twigs. The quantity of the waxy secretion was very much greater. It was noted only in a small number of bushes in a hedge opposite the Central College, where, however, it occurred in profusion. The

affected bushes appeared decidedly unhealthy and the formation of the flowers was greatly impeded. When examined again in June 1917, the mealy bug had almost disappeared, having been apparently checked by ladybirds and *Chrysopa*.

Large numbers were noticeable on the bushes of the same hedge in April 1919, and the attacked leaves had become crumpled up.

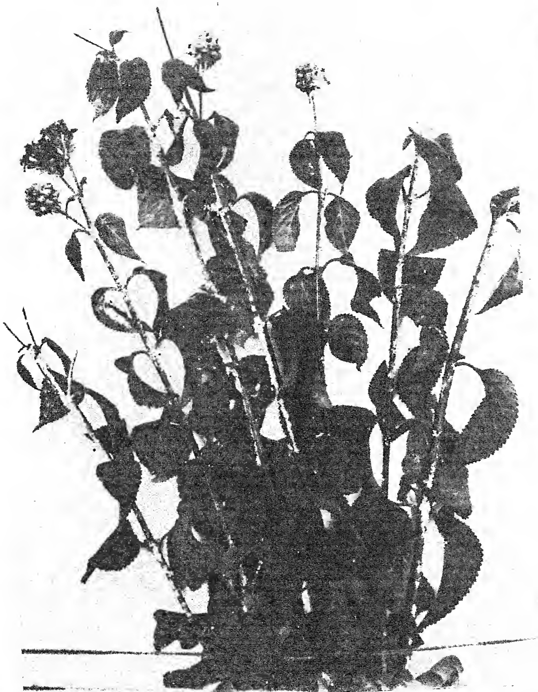
143. *Pseudococcus* sp. (Kathgodam). At Kathgodam some of the branches of several *Lantana* bushes were found harbouring probably a third species of mealy bug. The bugs were found clustering on the twigs and the young ones were noted both on the upper and the lower surfaces of the leaves and among the flowers and the fruits. It, however, did not occur in sufficiently large quantities to constitute a check on *Lantana*. (Plate XXXVI, fig. L.)

144. *Pulvinaria* sp. (Bangalore). In addition to the *Pseudococcus* sp., mentioned above, many of the bushes at Bangalore were also infested with scales, probably a species of *Pulvinaria*. The mature female individuals bore mealy ovisacs, like *Pulvinaria psidii*. They occurred chiefly on the twigs, but sometimes also low down on the stems and on the leaves. These were also attacked by ladybirds and a Chalcidid parasite. Observed in abundance in May 1917, it had almost disappeared in June 1917 at Bangalore. In July 1917, the same scale was observed on *Lantana* plants in small numbers about the 16th mile from Mysore along the Mysore–Hunsur Road.

145. *Icerya* sp. Small numbers of an *Icerya* were noted on *Lantana* at Manantoddy, Wynaad. It was however evident that they had strayed on to *Lantana* from a species of *Ficus* near by, on which they were found in abundance.

146. *Orthezia insignis*, Doug. The *Lantana* bug: the *Mani* blight of Hawaii.

I found this bug attacking stray *Lantana* plants on Barwood Estate, in the Ouchterlony Valley of the Nilgiri District. Introduced unwittingly along with garden plants either from Ceylon or from the West Indies, the first indication of the presence of this bug was, according to Mr. J. F. Nicholls, the Manager of the Estate, the absolute destruction in 1915 of a fine hedge of white *Lantana* planted around the Estate Bungalow. Specimens of the scales were forwarded by him for examination to Mr. Anstead, who transferred them to Dr. L. C. Coleman, Director of Agriculture, Mysore State. On receipt of information regarding the injurious nature of the insect, the infested *Lantana* hedge was cut out and destroyed by burning. The infested garden plants were also reported to have been similarly treated. At the time of my visit to Barwood on the 18th September, 1917, I was able to find, with the help of the



g. 1. Mealy-bug attacking *Lantana* twigs at Kathgodam, December 1918.

Fig. 2. *Lantana* twigs attacked by the bark fungus; Sagar, Mysore State, September 1918.

Estate writer, several stray *Lantana* plants round about the bungalow badly infested with *Orthezia*. The scale was also noted on the following weeds near by :—*Bidens pilosa*, *Ageratum conyzoides*, *Sida rhombifolia*, *Urena lobata* and one or two grasses, but only in small numbers. *Lantana* was evidently preferred. In one instance a dead bush of *Lantana*, with manifest traces of the scales on the twigs, was found around the base of a healthy *Citrus* tree which did not appear to have been attacked. Various garden plants including *Crotons* appeared to have suffered. The scale had appeared on tea in small numbers but did not do much harm.

The Manager of the Estate was informed of the recurrence of the scale on the Estate and was advised to have the whole patch thoroughly destroyed.

An outbreak of this scale-insect was reported in January-March 1919, to the Government Entomologist's office, Coimbatore, from the Audatode Estate, Perindotty P. O., near Vayitiri, Wynaad. The Manager, Mr. H. B. Winterbotham, reported : "Last year I cut down and burnt all the shrubs on which the scales appeared and saw nothing more of them for some months. For the last 3 or 4 months they have reappeared in great numbers and I have a great fear that they should get on to my tea."

The life-history of this bug appears to have been studied by Mr. Kunhi Kannan, the Senior Assistant Entomologist, Bangalore, and according to him *Lantana* plants infected by young scales in 1915 were completely killed by the close of 1917.

The circular issued by Mr. E. E. Green in 1899 about this scale-insect (*Trop. Agriculturist*, April 1899, p. 673) gives exhaustive information regarding the appearance of this insect in Ceylon. According to him this scale was first noticed in Ceylon in 1893 on garden plants in the Botanical Garden, Peradeniya, presumably imported from Kew Gardens, London. In 1894 it was first noticed to have appeared on *Lantana*. From Peradeniya it spread all round, into Kandy, Rangalla, Gampola, Nawalapitiya and Badulla. [It was common on *Lantana* at Diyatalawa in 1908—T. B. F.] According to Mr. Green, there may be as many as five generations during a year. Males appear to be produced only at long intervals and it is even doubtful if a generation of males is produced at least once a year. The original home of the insect probably lies somewhere about the West Indies, Mexico or British Guiana. The following foodplants are recorded by him :—

Acanthaceæ. *Crossandra, Justicia, Thunbergia, Meyenia, Strobilanthes.*

Rubiaceæ. *Cinchona*, Coffee, *Gardenia, Hamelia, Ixora* and many other common weeds.

Verbenaceæ. *Verbena citriodora, Lantana, Stachytarpheta, Duranta.*

Compositæ. *Tithonia* (wild sunflower), *Chrysanthemum, Achillea, Vernonia, Ageratum* (goat weed) and many common weeds.

Solanaceæ. *Habrothamnus, Capsicum,* "Tomato."

Labiatæ. *Coleus, Salvia.*

Rutaceæ. Orange and various kinds of *Citrus.*

Leguminosæ. *Clitorea.*

Caprifoliaceæ. *Lonicera* (Honeysuckle).

Bignoniaceæ. *Tecoma.*

Rosaceæ. Strawberry.

Amaranthaceæ. *Iresine.*

Ternstromiaceæ. Tea.

Convolvulaceæ. *Ipomœa.*

Lythraceæ. *Cuphea.*

The Imperial Entomologist has personal knowledge of its occurrence in Ceylon (*Proceedings of the Second Ent. Meeting, Pusa,* 1917). "The affected shoots die back and become black as if scorched, but the scale seems to occur only in patches and can hardly be looked on as an effective check."

In Hawaii, the ranchmen appear to have introduced it on *Lantana,* independent of the efforts of Mr. Koebele, who strongly condemned their action. It, however, was reported to be effective in killing *Lantana* in Hawaii.

According to Mrs. Fernald's *Catalogue of the Coccidæ of the World,* the habitat of this species includes England, South Africa, Mauritius, Ceylon, China, Brazil, Brit. Guiana, Trinidad, Jamaica, Mexico and the United States.

On account of the omnivorous nature of this scale it need not be stated that it is not an insect which can in any way be encouraged.

THYSANOPTERA

Suborder Terebrantia.

147............(not identified). This small Thrips is found abundantly in *Lantana* flowers throughout Southern India ; a similar and probably identical form was also noticed throughout Northern India and Burma.

At Sidapur and Bangalore, and in South India generally, two distinct forms were noted among the Thrips frequenting the flowers ; one was very dark blackish-brown, and the other very light coloured, a very pale yellow and much smaller. Examination under the microscope of specimens collected at Sidapur showed that the dark forms were invariably of the female sex, while the light ones were all males. Moreover, I have personally observed on more

than one occasion at Bangalore and Sidapur the light ones actively courting the darker forms and I have therefore no doubt that at least in South India there is a pronounced sexual dimorphism in this species. On the other hand, examination of specimens collected at Gurdaspur, Kathgodam and Pusa has revealed the presence of the light-coloured forms, but these were invariably of the female sex, the saw-like ovipositor being plainly noticeable. I do not know whether the North Indian form is a different species or whether the absence of the male individuals was only attributable to the effect of the season, all these specimens having been collected in the cold weather.

The eggs are laid in the tissues of the corolla and shine through the thin tube when held up against the light. They feed on the pollen and the nectar and also attack the tissues of the corolla, on which pale blotches are distinctly noticeable at the parts damaged. When Thrips are abundant the flowers look as if bleached all round the centres and present a distinctly woe-begone appearance. In bad cases of damage, fruits may not set, but usually the presence of the Thrips is helpful for the plant in the matter of fertilization, as was proved by the bagging experiments.

Suborder Tubulifera.

148............(not identified). Another Thrips, a jet-black one with an elongate body and a tubular terminal segment, was also noted on *Lantana* flowers in most places in India. It was present in much smaller numbers than the above-mentioned one. The eggs are laid free among the hairs on the tender buds. Generally they are not harmful, but a few instances were noted in Coorg where, due to the presence of this Thrips in abundance, the flower-clusters had withered up.

FUNGUS DISEASES.

(1) About 10 miles from Tumkur, Mysore State, a few *Lantana* plants were found dying along the roadside. On examination it was found to be due to the action of a fungus attacking the roots and the base of the stem. (Plate XXXVI, fig. 2.) Specimens of the diseased parts were taken to Mr. Ch. Noronha, who was then Mycological Assistant at the Bangalore Agricultural Laboratory, and were reported by him to have been attacked by one of the Polyporaceæ.

(2) Another distinct type of fungus attack was noticeable all over Coorg and the Wynaad, around Gudalur, around Sagar in Mysore, Malnad, and in parts of the Anamalai Hills. Leaves of individual branches were noted turning reddish and later on drying up. On examination, the cause was found to be due to the occurrence of a definite bark disease of the branches. The diseased

patches were clearly defined and varied in size and usually covered the whole girth of the twig or stem. They were brown in colour and were often covered on the surface by a network of fungus strands. In later stages small reddish papillæ pushed their way out through cracks in the bark. The bark both above and below the diseased patch was quite healthy but along the edges of the distal end of the diseased part a callus was developed, forming a pronounced thickening from which adventitious roots were given off.

This disease was noted in abundance in Coorg and the Wynaad, especially at Virajapet, Pandalur and Vayitiri, and in some cases whole bushes were affected, most of the branches showing evidences of attack. This disease, however, appears to be restricted to very rainy areas and is very much in evidence only at the close of the Rains.

Dr. F. J. F. Shaw, Second Imperial Mycologist, reported on 8th October, 1917, as follows on specimens forwarded in September 1917 from Gudalur :—"The specimens are infected with a basidiomycetous fungus belonging to either the genus *Corticium* or *Hyporhum*. Fungi of these genera are the perfect spore-producing stage of the sclerotial genus *Rhizoctonia*, and attack a number of important crops, *e.g.*, groundnut."

A detailed study of this peculiar disease would in my opinion be of much interest.

VEGETABLE PARASITES.

The Dodder (probably *Cuscuta reflexa*). *Lantana* was observed to be subject to the attack of a dodder at the following places :—Pyinmana (Burma), Dehra Dun, Kathgodam and Cawnpur.

It was, however, at Kathgodam and Haldwani that large quantities of this dodder were noticed on *Lantana*. At Haldwani whole hedges of *Lantana* were covered by the tangled masses of this plant and the attacked branches were distinctly unhealthy and did not put forth flowers or fresh shoots (Plate XXXVII). This plant parasite would however appear to flourish only in very rainy areas.

8. CONCLUSIONS.

As may be noted from the preceding list, a fairly large number of insects has been found feeding on *Lantana*, especially in South India, but few of these are really important. The most efficient of all is undoubtedly the Plume-moth, *Platyptilia pusillidactyla*. It is found throughout India except perhaps in the Punjab, and has an almost world-wide distribution. In India it also breeds in *Lantana indica* and *Lippia geminata*. The multiplication of *Lantana* seeds is checked to a considerable extent but, being itself kept in check by

PLATE XXXVII.

Dodder on *Lantana* hedge at Haldwani, U. P., December 1918.

parasites, the insect is not very efficient. The various microlepidopterous caterpillars, such as *Lobesia* and *Cacœcia*, are not found in sufficient numbers to prove efficient checks. The Lymantriads, such as *Euproctis* spp. and *Olene mendosa*, would be efficient if they occurred in sufficient numbers, but as they also attack cultivated plants, they cannot be encouraged. The Noctuid caterpillar, *Hypena* sp., as well as the Arctiads are chiefly leaf-feeders and are not so useful as those that feed only on the flowers and thus directly control seed-formation. The gall-fly, *Asphondylia* sp., even when it occurs in abundance, is of low efficiency and as it is very probably identical with *Asphondylia* * *sesami*, which is fairly serious on *til* at Coimbatore and Nagpur, ought not to be introduced into new districts. Of the bugs, *Plautia, Nezara*, etc., are found feeding on fruits, while others attack the flowers, *e.g.*, the small green Capsid ; but it is doubtful if the bugs, on the whole, are really efficient. The *Lantana* bug, *Orthezia insignis*, which has been unconsciously introduced into the Wynaad, is on the other hand, an efficient check on *Lantana*, as it is known to kill bushes outright, but owing to its well-known polyphagous nature it is an insect whose presence ought not to be tolerated.

The nett result of the present inquiry appears unmistakably to indicate the absence at present of any indigenous insect capable of checking the spread of *Lantana* in India. However, at least in parts of India, some insects are sufficiently numerous to serve as auxiliaries, if an efficient insect of the nature of the *Lantana Agromyza* were to be introduced.

Failing the presence of an indigenous insect check on *Lantana*, the question of the importation of the seed-fly may perhaps be considered next. The following three aspects of the question appear to be important: (1) Is the introduction of the Agromyzid *necessary* ?, (2) is it likely to be *useful* ?, and (3) is it *safe* ?

The *Lantana* plant is an instance of a vegetable pest that has been introduced without its natural check and the most rational method would appear to be to restore the equilibrium of Nature, always assuming that the importation will not upset it in other directions in the new country. Mechanical eradication may by itself be sufficient to check *Lantana*, but usually the plant again regains its original dominance after a time, if it is not periodically kept down. Considering the extent of land over which *Lantana* has established itself, the cost of eradicating it over the whole area will be enormous, and there is therefore no doubt as to the superiority of this method over mechanical destruction. Again the seed-fly simply acts as a check on the spread of the

* It is quite distinct from *A. sesami*. [T. B. F.]

plant but does not destroy it, so that the measure will be able to satisfy the party that considers it a nuisance as well as the one that regards it as beneficial.

As to the usefulness of the introduction, we have to depend on the experience of countries where the measure has been tried. In Hawaii (*Trop. Agriculturist*, April 1904, p. 657) Dr. Perkins reported that out of the 8 Mexican insects which he liberated, "the success of the *Agromyza* was instant and phenomenal." Mr. D. T. Fullaway, Entomologist, Division of Entomology, Honolulu, wrote as follows in reply to an inquiry made by the Imperial Entomologist: "My own personal experience only goes back ten years, but I think I am justified in saying that the spread of *Lantana* has been distinctly checked, if not altogether stopped, and that was the result desired. The principal agents in this work are the Agromyzid fly and the moth borer [probably *Platyptilia*] which works in the flower-heads. As far as I know, these insects have confined themselves entirely to *Lantana*."

Successful results are reported from Noumea (New Caledonia) and Fiji where the seed-fly alone had been introduced. It is reported that in Fiji nearly 95 per cent of the fruits were found infested, and there appears to be little doubt that an introduction of the seed-fly into India will be as efficient as in other places.

Mr. W. W. Froggatt, Entomologist, New South Wales, however, sounded a warning note in commenting on the introduction of the fly into Fiji. "Though the *Lantana* berry parasite has been in Hawaii since 1906, there is still plenty of *Lantana* on the waste areas, and it is not claimed by its advocates that it kills *Lantana* at present occupying the land. Residents of the North coast have at various times requested that the fly should be introduced, but it is considered that the conditions in Australia are so different to those of an island where the main crop may be sugarcane or coconuts, that no berry- or seed-eating fly should be brought in. A fly that attacks *Lantana* berries might very possibly attack many things commonly grown in Australia."

It is to be admitted that it is always a dangerous measure to introduce foreign insects, without first knowing everything about them. Even if an imported insect be innocuous in its original home, it is quite possible that in the country of its adoption, it may, owing to the effect of new environments, suddenly change its habits and develop into an injurious insect.

As far as the *Agromyza* is concerned, the evidence seems to point out that it is a safe insect to introduce. The views of Mr. H. Tryon, Government Entomologist, Queensland, on this point were published in the *Queensland Agricultural Journal*, April 1917, p. 183: "The introduction of the insect would

present no interference with the use of *Lantana*, by those who desired to do so, as a cover-crop or as a means of honey production. The habits of the fly, so far as they relate to forms of vegetation other than *Lantana*, had also been under close observation for years. It was, therefore, possible to affirm that neither in its native home, Mexico, nor in any of the countries into which it has been introduced, has it ever associated itself injuriously with any plant other than *Lantana*. There was no ground for any suggestion that the insect was likely to change its habits, the experience being that in the absence of *Lantana* no propagation took place and that eventually it died."

The seed-fly has been existent in Hawaii since 1902 and has therefore been long enough there to have definitely declared tendencies, if any, of turning its attention to other plants. The cultivated plants of Hawaii and India are very likely to be identical, both being parts of the Tropics, and as far as the crops are concerned the insect may therefore be considered safe. The general flora of the two countries is, however, likely to be very different, as they belong to different regions botanically. Many of the important Verbenaceous plants of India, for example, teak, are absent from Hawaii and unless actual experiments are made, it is impossible to say whether these Indian Verbenaceous plants will be free from its attacks. As far as teak is concerned, I am of opinion that the fruits, which are different both in size and structure from those of *Lantana*, are not likely to be attacked. The only plant which is likely to be infested, in India, appears to me to be *Lantana indica*, happily a plant without any economic significance.

Moreover, unlike scale-insects which are able to adapt themselves to almost any plant, the seed-fly is a type of an insect with specialized habits. The Agromyzid, that breeds in the seeds of *Cajanus indicus* in India, has not been reared from any other plant in India, and I should think that it is as unlikely that the *Lantana* Agromyza would turn its attention to any other plant except perhaps *L. indica*. It is, however, very important that as close a study as possible of the insect in relation to its behaviour with regard to the Verbenaceous plants in Hawaii* and to those of India under control in cages be made, before the actual liberation is contemplated.

The Agromyzid appears to be subject to the attacks of a parasite both in Hawaii and Fiji and since the efficiency of the fly is likely to be greatly reduced if the parasite is also brought in, measures might be adopted to bring about the elimination of the parasite.

* It is however unfortunately the case that practically no Verbenaceous plants, other han *Lantana* occur in Hawaii. [T. B F.]

Moreover, an attempt appears to have already been made, a few years ago, by Dr. L. C. Coleman of Bangalore, to import the maggots and pupae of the fly under cold storage, from Hawaii, but it was not successful as the flies died during transit. It must of course be always kept in mind that our aim in seeking to introduce this fly is to check the spread of the plant by reducing the production of sound seeds and in case this object is accomplished, *Lantana* would settle down into the rank of many a harmless weed whose presence we do not very much care about.

9. OTHER PESTILENTIAL WEEDS.

Lantana is not by any means a unique instance in India of an introduced plant that has assumed the status of a troublesome weed. The following are notes of some of the observations, made in the course of the present inquiry regarding certain plants which I found running wild under certain peculiar conditions.

Prickly Pear is a familiar example of an introduced American plant which has proved a troublesome pest like *Lantana* but capable of thriving only under very different conditions. Whereas *Lantana* appropriates the moister areas, Prickly Pear flourishes best in dry and almost desert conditions. It appears to have been imported into India more than a century and a half ago in connection with the cultivation of the cochineal insect for the sake of its much prized dye. In most cases, however, the wrong species of the Cactus appears to have been imported, such as *Opuntia Dillenii* and *Opuntia nigricans*, on which the true cochineal insect, *Dactylopius coccus*, "grana fina," did not thrive and again in a great many cases, the wrong species of the cochineal, the wild cochineal insect, "grana sylvestre," *Dactylopius indicus*, Green, which increased to such an extent on the real Cochineal cacti, *Opuntia monacantha* and *Nopalea cochinelifera*, as to lead almost to their extermination in India. Though the cochineal industry failed, the Cacti got established and have assumed pest conditions in waste-lands around villages in the drier parts of India.

Then there is the Sensitive plant, *Mimosa pudica*, originally a native of Brazil, which has become established in many of the moister areas of India and Burma. It is a pest of a bad type in the lowlying lands and the pasture grounds in Coorg. It covers up and suppresses the grasses and is felt to be a nuisance, as its prickles produce sores of a septic nature on the bare feet of agricultural labourers. It is chiefly spread by goats which feed on the pods and broadcast the seeds along with their droppings. In fact, I have heard

many people in Coorg and Malnad stating that they considered *Lantana* the less serious of the two evils.

There is next the remarkable case of the Water Hyacinth, *Eichhornia crassipes*, "*Beda-ben*" (Burmese), which has spread with phenomenal rapidity throughout India and Burma within about a decade of its introduction. Originally a native of Tropical America, it was introduced as a rare plant in Botanical Gardens, and very soon travelled from tank to tank owing to the possession of fascinatingly beautiful flowers. It, however, did not take a long time for people to discover the real nature of the plant, but by then it had already begun to infest all fresh water ponds, pools and water-channels.

There is another plant, the potentialities of which seem yet to be but little realized, that is spreading with alarming rapidity in the moist areas of Burma, Assam and Bengal. It is *Eupatorium odoratum*, Linn., a weed belonging to the order Compositæ, the place of origin of which according to the *Index Kewensis* is Tropical America. Hooker remarks in his *Flora of British India* "that it is a West Indian plant cultivated but rarely in India," and Prain in his *Bengal Plants* notes that "it is cultivated sparingly in Central and East Bengal, a coarse herb." In Burma it is known as "*Bi-zat*" or "*Taw-bizat.*" In Assam, it appears to be known by the following interesting and expressive vernacular names, for which I am indebted to Rai Bahadur Upendranath Kanjilal, Retired Extra Deputy Conservator of Forests—

Tongal-lati.—(Assamese; lit., split bamboo creeper.)

Sam khabli.—(Kachari; lit., Kabul Plant; so named as it is believed to have been spread by the Kabuli coolies employed when constructing the Assam-Bengal Railway.)

Kombat-nong-rim.—(Khasi; lit., plant of old abandoned villages.)

Kal-bun.—(Mikir; lit., new weed.)

Rél-Hlow.—(Kuki, Lushai Hills; lit., the railway herb.)

San-khauri.—(Sylhet; lit., eater of thatching grass.)

Burma-chik.—(Tipperah; lit., Burma plant.)

It was Col. G. H. Evans, Superintendent, Civil Veterinary Department of Burma, who first drew my attention to the presence of this plant in Lower Burma, and gave the information that, of late years, it was making extensive inroads into the jungle, covering up wide areas. In his opinion, it was far worse than *Lantana*, which was after all not important so far as Lower Burma was concerned. He also informed me that it was popularly known in Rangoon as the "Curse of Ceylon," being believed to have been imported from that Island. At Moulmein, I was informed by the Deputy Commissioner that it was locally known as "Camphor grass" and also as the "Siam weed."

According to him it is believed to have been brought in by a cyclone from over the Siamese borders, a not improbable view since the seeds are wind-borne and very light.

On the other hand, Mr. C. G. Rogers, Chief Conservator of Forests, Maymyo, was of the opinion that it was an indigenous species, probably found all over Burma, but I have very little doubt that it is an imported plant which has, very much like *Lantana*, got out of control.

As to its distribution in Burma, Mr. Rogers furnished me with the following note :—"It is spreading rapidly from Moulmein and Rangoon up both Railway lines (main line to Mandalay and line to Prome). It is common in Kodan-chaung in the Upper Chindwin District and I have seen it in the Reserved Forests in the Pyinmana District. It grows very prolificly in the Tenasserim Civil Division, where it is reported to be doing considerable damage to teak plantations in the Thangyin Division. It is interfering with a teak plantation near Kodugwe in the Tharrawaddy Forest Division made in 1914."

I found this plant "*Bi-zat*" in great abundance chiefly in Lower Burma, large masses being noticeable around Moulmein, Pegu, Pyinmana, and Rangoon. It was, however, along the railway line between Thaton and Pegu and particularly between Hninpale and Kyaikto, that this plant showed an extravagant exuberance of growth, unequalled even by *Lantana*, extraordinarily dense thickets covering extensive areas of jungle-land being noticeable.

I did not notice "*Bi-zat*" in the dry region of Central Burma (Thazi, Meiktila and Mandalay) nor anywhere in the Northern Shan States. In Upper Burma I found this plant growing wild only in two situations along the line from Mandalay to Myitkyina, in a private garden near the Kotaungbo Railway Station, and secondly on either side of the railway line between Nankan and Bouchaung, where it passes through very hilly country along the side of a great ravine. The plants were found along the sides of the track and must have been unwittingly introduced, as in Assam, by gangs of coolies working at the construction or repairs of the bridges near by.

In the Southern Shan States I found a few bushes of "*Bi-zat*" growing near the platform of the first reversing station, between Lebyin (1,500 ft.) and Hmodon (3,900 ft.) on the hill section of the Thazi-Kalaw line. It may have been introduced along with garden seeds imported by the station staff. A few plants were also found a short distance further up the line.

From information collected from the Forest Department in Assam, this plant is now to be found spread throughout the Province. It is noticeable in

extraordinary abundance on the sides of the hills around Gauhati, and also all along the Shillong-Gauhati Road up to a height of about 3,000 ft. The Garo and the Lushai Hills are reported to be covered up by masses of this weed, while in the Surma and the Brahmaputra Valleys it is reported to have followed in the wake of the construction of the main line of the Assam-Bengal Railway running from Chittagong to Dibrugarh. In Bengal I have observed it growing in abundance on either side of the main line of the E. I. Railway from about the 30th mile stone to very near Howrah.

The plant grows into a large bush, the branches of which have a tendency to elongate and overtop all other low vegetation and cover it up with its dense foliage. It appears to be a perennial; the light blue flowers, the petals of which are filament-like, are produced in enormous masses at the end of the rains and when ripe set free quantities of the light pappus seeds, which get widely distributed through the agency of the wind.

I have not noticed this plant anywhere in the United Provinces nor in the Central Provinces or South India, and the possibilities of its spread in damp areas, like the West Coast of India, where climatic conditions are very much as in Assam and Burma, are indeed very great, and I am of opinion that precautions ought to be taken to prevent its spread into regions which it has not yet reached.

Lippia geminata, originally a native of North and South America, is another introduced garden plant, which has shown definite tendencies of spreading. It is a small shrub with smooth and velvety silver grey leaves characterized by a fine *Citrus* scent and light purplish flowers borne on elongate spikes. It is plentiful on the banks of the River Gandak at Pusa and I have noticed it growing in abundance all along the sides of the B. & N.-W. Railway line between Chapra and Sonepur, and between Barauni and Katihar, forming dense masses in lowlying areas by the side of the rivers. In Bengal and in Assam and in parts of Orissa it was noticed in similar situations. Rai Bahadur U. Kanjilal informed me that he had found this plant, which according to him is known to the Assamese as "*Pichas lakdi*" (or devil stick), spreading in lowlying areas near rivers in the Brahmaputra Valley. This plant was also noted by me on the plateau of the Khasi Hills. In South India, the only place I have noticed it is on the banks of a canal at Chettipalayam Cane-Breeding Station where it was introduced from North India by Dr. C. A. Barber.

Several Australian Wattles have been introduced into the Nilgiris, especially *Acacia dealbata*. Though they are undoubtedly of economic importance, the wood and the bark especially being useful, they have shown definite

tendencies of aggressiveness. Not only are the seeds produced abundantly but the plant is capable of spreading by a system of suckers, so that, when once an area has been planted with it, it appears to be extremely difficult to get rid of. When planted with other forest trees, it is reported to have the effect of choking up the rest.

Jatropha gossypifolia (Tropical Asia and Africa) is another plant which under peculiar conditions has been noted increasing in abundance and covering up the ground.

In addition to the above, there are several garden plants which have shown similar tendencies. Around some of the Hill Stations it is not an uncommon sight to find *Zinnia* and *Cosmos*, both American plants, straying in numbers into pastures and open waste-lands. At Gudalur in the Nilgiri Wynaad, a balsam, *Impatiens balsamina* ?, has escaped into waste areas and was found growing in masses, even on the tops of the tiled buildings in that moist tract. A perennial sunflower which I found cultivated in a great many places in India and Burma also exhibits tendencies of running wild.

There are two European plants, *Ulex europæus* and *Cytisus scoparius*, which have been introduced in the Nilgiris through the agency of the Nilgiri Hunt, that have shown aggressive tendencies.

Lastly there are certain indigenous plants which have, possibly due to the displacement of the balance of Nature by man, been found to spread exceedingly so as to form a serious factor sometimes in forestry, such as species of *Strobilanthes* in Burma and the Western Ghats, *Urtica dioica* (*Bichchu*) in the Himalayas, and *Pogostemon plectranthoides* in the Nilgiris and Central Provinces.